In the Supreme Court of the United States

OCTOBER TERM, 1942.

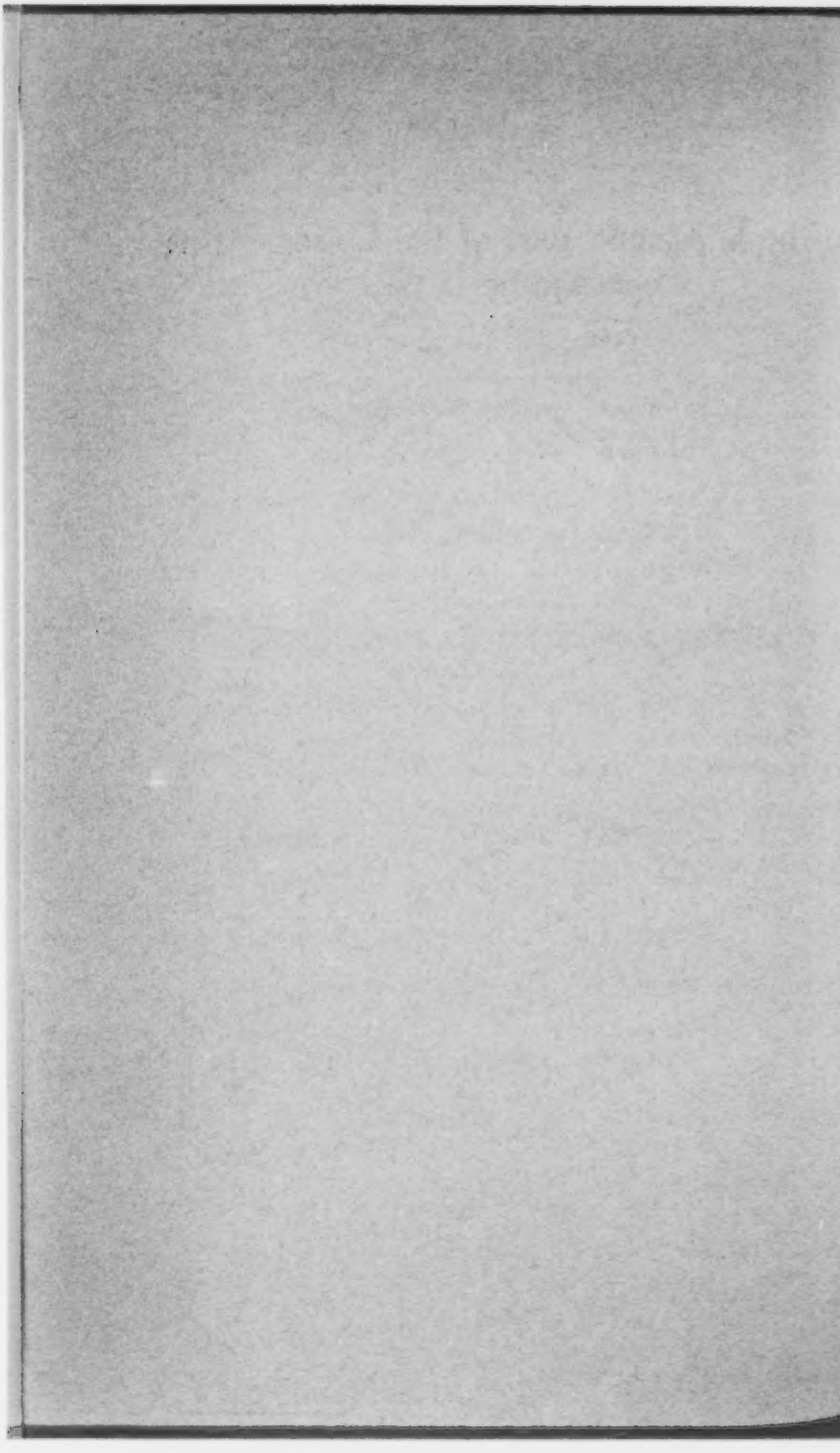
No. .....

THE SWAN CARBURETOR COMPANY,
Petitioner and Appellant Below,

vs.

CHRYSLER CORPORATION,
Respondent and Appellee Below.

APPENDIX TO BRIEF OF PETITIONER.



APPENDIX.

Report of the Special Master
In the Case of Swan v. Reeke-Nash,
Northern District of Ohio,
Eastern Division, Equity No. 2047.

REPORT OF WM. B. WOODS, SPECIAL MASTER.

(Filed August 21, 1933.)

To the Honorable Paul Jones, S. H. West and Geo. P. Hahn, Judges of the District Court of the United States, For the Northern District of Ohio, Eastern Division:

Pursuant to an order made and entered in this cause on May 26, 1932, at a term of this Court held in the City of Cleveland, in said District, the undersigned, Wm. B. Woods, Special Master in Chancery, has proceeded to take and hear the evidence offered by the respective parties and to report his findings and conclusions along with his recommendations concerning the relief demanded, to this Court; and further,

Pursuant to said order there is stipulated into this cause by agreement of counsel, the pleadings, evidence, proofs and exhibits, including the affidavits, testimony, exhibits, and substantially all other matters heretofore

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*** The boldface page headings and folios in this Report of the Special Master refer to the pagination of the Record in the case of Swan v. Reeke-Nash.**

filed, taken, submitted, offered or adduced in the case of *The Swan Carburetor Company v. General Motors Corporation,* at Law No. 14,169 in this Court, and there is included herein such parts of said record as the parties hereto have offered for the record in this case; therefore,

I, Wm. B. Woods, as Special Master in said cause, do respectfully report that I have proceeded to investigate the matters so referred to me, that I have been attended by the parties and their respective counsel at my office at 1214 Terminal Tower Building, Cleveland, Ohio; that pursuant to said order I proceeded to hear witnesses and counsel to receive and consider testimony, affidavits, exhibits and other proof, including that heretofore filed, submitted, taken, adduced and stipulated into this case as aforesaid or otherwise, to examine and consider pleadings, proof, briefs, arguments, and any and all other papers or matters relating to the questions involved and the issues raised herein, to rule on the admissibility of evidence, but have preserved such evidence as counsel has demanded, which the Master deemed inadmissible, together with his ruling thereon for the ultimate and final ruling by the Court, to observe such tests and experiments as the parties performed or caused to be performed, and to hold the sessions within the District and Division of this Court, at such time as directed, and thus to hear and consider all the proof and argument pertinent to the issues of law and fact arising in the cause. Such hearings have been had; arguments of counsel have been had, briefs of counsel have been filed, together with suggested findings of fact and conclusions of law, and upon consideration of the same, I find and report as follows:

PLEADINGS.

This is a suit for infringement filed November 3, 1926, on Swan Patent No. 1,536,044, for "method and means to facilitate distribution of fuel in internal combustion engines." A supplemental bill of complaint was filed September 23, 1927, alleging infringement of the Swan Patent No. 1,636,721, for a "manifold."

Although this was the second patent to issue, it was issued on an application filed September 17, 1921, Serial No. 501,314, of which the application Serial No. 747,991 filed November 5, 1924, for the first Swan Patent, was a continuation in part. The pleadings also include answers, amendment to answers, motions and stipulations.

The alleged infringements are the manifolds made by The Nash Motors Company and sold by the defendants in the year 1926, and were used in Nash automobiles known as Special Six, Advance Six and the Ajax.

MANIFOLDS, SUBJECT MATTER OF THE SUIT.

The subject of the invention involved in this suit is an intake manifold for use in an automobile. The intake manifold is a pipe connecting the carburetor with the cylinders of a motor. The function of the carburetor is to mix the liquid fuel with air by means of its mechanism, which mixture must be conveyed to the cylinders of the engine wherein the mixture is to be exploded. This manifold pipe is connected at one end to the outlet from the carburetor as a single pipe, which part of the manifold is called a "riser," and this "riser" enters a transverse pipe called a "header," and this "header" divides into the number of pipes sufficient to connect with all the ports of the cylinders. These pipes from the "header" to the cylinders are called "branches." Sometimes one "branch" feeds one cylinder with fuel, sometimes two cylinders, and when a single branch feeds two cylinder ports they are said to be "siamesed." In some manifolds there are branches siamesed and another branch or branches for a single cylinder.

The fuel mixed with air is drawn by the suction of the cylinders out of the carburetor through the riser, the header and the branches into the cylinders. The products of combustion caused by explosions in the cylinders pass into an "outlet or exhaust manifold" and are usually conveyed in a hot condition around or adjacent to the "riser" of the inlet manifold so as to heat it or to form a "hot spot."

The Swan Patents describe the form of intake manifold which is sometimes known as a "T" manifold of rectangular or square cross-section. As used herein, a "T" manifold is one in which there is a vertical riser leading from the carburetor to the longitudinal header of the manifold. In this riser there is the usual butterfly throttle valve. At the juncture of the riser and the header the forward and rear branches of the header and riser form the letter T. That portion of the manifold which is at the top of the riser and from which there are three passages, is referred to as the "T," and in the Swan Patents this is referred to as the "distributing zone."

ISSUES.

The two *General Motors cases* heretofore tried concerned liability on a royalty contract for the use of the Swan patents. The entire record in case No. 14,169 is stipulated into the record in this case and certain portions of the record in the second case, No. 16,366, are also stipulated into this record. The license there involved was taken by the General Motors Corporation, which included the Buick Motor Company in June, 1923, when application for the second Swan patent was the only one then pending in the Patent Office.

In the *General Motors cases*, after the Buick Company notified plaintiff in the Spring of 1924 that it intended to give up the square section manifold and use a round section manifold, the application for the first Swan patent was filed on November 5, 1924, as a "partial continuation" of the application for the second patent.

The second Swan patent, No. 1,636,721, issued on the earlier application, and its claims 5, 7 and 8 in issue being limited to manifolds with straight ducts which change direction at right angles to each other and "devoid of curves * * * in the direction of the flow of the fuel mixture." The defendant here asserts there is no infringement of the manifolds in issue which are circular in cross-section and which it asserts are replete with curves. Defendant further asserts that if the claims are construed to cover defendant's manifolds they are met by the prior art.

Defendant further asserts that until the application for the second patent, on November 5, 1924, there had been no claim that a round section manifold was within the scope of the Swan's invention.

In the second Swan application claims are made which are asserted to be broad enough to cover a round section manifold.

In this situation the defendant asserts that the so-called "Swan method" claimed in the first Swan Patent which issued on the second Swan application, is a false and mythical mode of operation. Defendant asserts that this "method" is non-existent and that the claims thereto in the first Swan Patent are invalid.

The issues are thus resolved to this, plaintiff asserts (1) that the Swan manifold operates like and employs the method described in the Swan Patents, and (2) that the Swan manifold realizes equal distribution. Both asser-

tions are denied by defendant and other items in dispute between the parties are collateral to these main questions in issue.

FACTS ADMITTED OR AGREED TO BY BOTH PARTIES.

(1) The plaintiff, The Swan Carburetor Company, is and was a corporation of the State of Ohio having its principal place of business at Cleveland, Ohio, as alleged in the bill of complaint and the supplemental bill of complaint, and is the sole owner of the entire right, title and interest in and to the inventions and patents in suit along with the whole right to recover for all the infringement therein complained of and to be awarded the relief prayed for in the bill of complaint and supplemental bill of complaint. The Swan Carburetor Company is properly the sole plaintiff here having all the right, title and interest of every nature whatsoever which formerly rested in the joint plaintiffs named in the bill of complaint and supplemental bill of complaint, as appearing in the stipulation and order, plaintiff's Ex. 3, made by reference a part hereof.

(2) The defendant, The Reeke-Nash Motors Company, is and was an Ohio corporation, and has and had a regular and established place of business at Cleveland, Ohio, as alleged in the bill of complaint and supplemental bill of complaint.

(3) Both The Reeke-Nash Motors Company and The Nash Motors Company were named as defendants in the original and supplemental bills of complaint, the defendant, The Reeke-Nash Motors Company, alone filed its answers to the bill of complaint and the supplemental bill of complaint. The defendant, The Nash Motor Company, was not served and made no answer to either the original bill of complaint or the supplemental bill of complaint.

(4) The manifolds charged by plaintiff to infringe the patents in suit were all made, used and sold in connection with six cylinder engines, and all comprise a riser, header and branches, of which typical risers are shown in plaintiff's Ex. 50, which is by reference made a part hereof, and of which the header and branch portions, with certain integrally formed risers, are shown in plaintiff's documentary exhibits 40 to 46 inclusive, part of which by corresponding numbers are also illustrated in plaintiff's physical exhibits 41A, 42A, 43A, 45A and 46A,

all of which by reference are made a part hereof. The said manifolds and engines were made or caused to be made by The Nash Motors Company, knowing and intending that certain quantities of them were to be used and sold by the defendant, The Reeke-Nash Motors Company. Such manifolds and engines were used and sold by The Reeke-Nash Motors Company in the Northern District of Ohio, Eastern Division, prior to the filing of the original bill of complaint and the supplemental bill of complaint and subsequent to the issuance of the respective patents in suit.

(5) The defense of this suit is made by the answer and pleadings of the defendant, The Reeke-Nash Motors Company; and in accordance with Article VI of the constitution of the National Automobile Chamber of Commerce, Inc. (plaintiff's Exs. 74 and 144), and at the request of the Nash Motors Company, the said Chamber of Commerce assumed and is carrying on and controlling the defense of this suit, selected counsel therefor, and has assumed the payment of all expenses of said defense; and said Chamber of Commerce has assumed and is carrying on and controlling the defense of the pending suits brought by the plaintiff on the same patents against its members, The Nash Motors Company, the Reo Motor Car Company and the Willys-Overland Company, selected counsel therefor, and has assumed the payment of expenses of such suits.

(6) The patent in suit, No. 1,636,721, was issued July 26, 1927, to John W. Swan on application for Letters Patent in the United States, Serial No. 501,314, filed September 17, 1921, and the patent in suit, No. 1,536,044, issued April 28, 1925, upon an application for Letters Patent in the United States filed by John W. Swan, Serial No. 747,991, November 5, 1924. The later application and earlier patent refer to the earlier application and is a continuation of the earlier application as stated in said patent.

(7) The patent in suit, No. 1,536,044, along with its complete file wrapper and contents including the application Serial No. 747,991, and the application Serial No. 501,314, along with its complete file wrapper and contents up to and including the amendment of March 3, 1927, were exhibited to the Court for the Northern District of Ohio, Eastern Division, in the case of *The Swan Carburetor Company v. General Motors Corpora-*

tion, at Law No. 14,169, decided by Judge Westenhaver, 42 Fed. (2) 452, affirmed by the Court of Appeals (C. C. A. 6) 44 Fed. (2) 24. Both of the patents in suit, along with the complete file wrapper and contents of each of them, were exhibited to the Commissioner in the case of *The Swan Carburetor Company v. General Motors*, at Law No. 16,366. In both of the foregoing cases the invention or inventions and improvements disclosed and claimed in the patents in suit were considered, and discussed by the tribunals which heard and decided the issues therein raised, which appertained to the said invention or improvements and said patents and applications.

(8) The issues in this case are in many instances the same as the issues in the first *General Motors case* hereinbefore referred to. The parties are represented by the same counsel, and the major portion of the testimony and exhibits submitted in the first *General Motors case* would have had to be adduced and submitted again in this case, except for the agreement of counsel to stipulate such testimony and exhibits into this case as if it had been taken here in the first instance.

(9) The Buick manifolds, plaintiff's Exs. 6 to 11 inclusive, and including the risers and Marvel heaters for which this plaintiff recovered royalties in the action at Law No. 14,169 against General Motors Corporation hereinabove referred to, are substantially identical with defendant's manifolds here charged to infringe, plaintiff's Exs. 40 to 46 inclusive and the physical exhibits hereinabove referred to, and including the risers and Marvel heaters, plaintiff's Ex. 50. The Buick manifolds including the risers were used with six cylinder engines, as were and are all of defendant's manifolds here charged to infringe.

(10) The claims selected to exemplify the invention and as the basis for the charge of infringement of the first Swan Patent No. 1,536,044 are method claims Nos. 4, 5, 8, 9 and 10, as follows:

> 4. A method of distributing a fuel mixture to an engine which consists in moving the mixture in a straight line to a zone from which it is distributed to a plurality of engine cylinders, directing said movement by forces which tend to distribute the mixture uniformly in all directions in a plane transverse to said movement, and further directing the

movement of the mixture by forces tending to move it successively in a plurality of directions transverse to the original direction, to the cylinders.

5. A method of distributing a fuel mixture to an engine which consists in moving the mixture to a zone through which it is distributed to a plurality of engine cylinders, modifying said movement by forces tending to distribute the mixture in uniform character in various directions in a plane transversely of said zone, and further subjecting the movement of the mixture to forces acting to prevent impairment of the character of the mixture due to influences created by any changes of direction beyond the zone.

8. A method of distributing a fuel mixture to an engine which consists in moving the mixture to a zone through which it is distributed to a plurality of engine cylinders, subjecting said movement to forces acting to distribute the mixture in uniform character in three directions in a plane transverse to said movement, and further subjecting the movement of the mixture to forces acting to prevent impairment of the character of the mixture due to influences created by any changes of direction beyond the zone.

9. A method of distributing a fuel mixture to a six-cylinder engine which includes the moving of the mixture to a zone through which it is distributed in three directions in a plane transverse to said movement, and subjecting said movement to forces tending to distribute charges in alternating directions and in uniform character in all of said directions.

10. A method of distributing a fuel mixture to a six-cylinder engine which includes the moving of the mixture to a zone through which it is distributed in three directions in a plane transverse to said movement, subjecting said movement to forces tending to distribute charges in alternating directions and in uniform character in all of said directions, and further subjecting the movement of the mixture towards adjacent pairs of cylinders to forces tending to qualify the charges for said pairs in substantially equal proportions of wet mixture constituents.

Also of the first Swan Patent are included apparatus claims Nos. 11, 12, 13, 20, 22 and 23, as follows:

11. An inlet manifold comprising a distributing chamber having a single inlet conduit and a plurality of outlet conduits, said chamber being formed of walls the intersections of which form straight lines.

12. In an inlet manifold, a distributing chamber having a single inlet conduit and a plurality of outlet conduits, said chamber being formed of walls the intersections of which form straight lines, the inlet conduit being at right angles with all outlet conduits.

13. In an inlet manifold, a distributing chamber having a single inlet conduit and a plurality of outlet conduits, said chamber being formed of walls the intersections of which form straight lines, one of said walls being opposite the inlet duct and symmetrically shaped and situated relative thereto, so that entering mixture may be influenced by said wall uniformly in all directions transversely to the entering stream.

20. In an inlet manifold, a distributing chamber having a single inlet conduit and three branch conduits, one of the walls of the chamber being opposite the inlet duct and symmetrically formed and situated with reference to the branch ducts so that entering fluid may be influenced by said wall uniformly in all directions transverse to the entering stream, and the branch conduits being of substantially uniform shape throughout and at any turn thereof presenting similar walls shaped and situated so that passing mixture may be influenced thereby in a manner to distribute equally to cylinders to which said turns may lead.

22. In combination with a six cylinder engine, a manifold comprising a distributing chamber having an intake and three outlets each leading to a pair of cylinders, the wall of each leading to a pair of cylinders, the wall of the chamber opposite the intake being symmetrically formed and situated with reference to the outlets to uniformly influence entering mixture and cause the same to distribute in uniform character in the successive directions determined by the outlets and induction cycles of the engine.

23. In combination with a six cylinder engine, a manifold comprising a distributing chamber having an intake and outlet branches, the wall of the chamber opposite the intake being symmetrically formed and situated with reference to the outlets to uniformly influence entering mixture and cause the same to distribute in uniform character in the directions determined by the outlets and induction cycles of the engine, the outlet with the intakes of pairs of cylinders, and the angular formations being shaped and situated so that passing mixture will be influenced thereby in a manner tending to distribute equally to the cylinders of the pair to which the branches respectively relate.

Of the second Swan Patent, No. 1,636,721, there are included apparatus claims Nos. 5, 7 and 8, as follows:

5. In a manifold for a six-cylinder internal combustion engine, the combination with a main manifold duct, level throughout its length, a straight or substantially straight riser duct connecting the carburetor with the central part of the main duct and being at right angles, or substantially at right angles thereto, the interior or the connection of the riser to the main duct being at a substantially uniformly sharp angle all around the connection, three secondary ducts each for connecting the main duct to two of the engine cylinders, the middle secondary duct being connected to the main duct at the junction of the riser with the main duct and at right angles, or substantially right angles thereto, a distributing zone with a non-recessed roof being formed at the junction of the main duct, the riser and the middle secondary duct, the two other secondary ducts being connected to the main duct at the ends thereof, all of said secondary ducts being parallel, or substantially parallel to each other and perpendicular or substantially perpendicular to the main duct, on the interior the end secondary ducts making a right angle connection with the main duct at the sides nearest the middle and the middle secondary duct making a sharp connection with the interior of the main duct, and all of said ducts and riser being devoid of curves and recesses in the direction of flow of the fuel mixture.

7. In a manifold for a six-cylinder internal combustion engine, the combination with a main

manifold duct, level throughout its length, a straight or substantially straight riser duct connecting the carburetor with the central part of the main duct and being at right angles, or substantially at right angles thereto, the interior of the connection of the riser to the main duct being at a substantially uniformly sharp angle all around the connection, three secondary ducts each for connecting the main duct to two of the engine cylinders, the middle duct with the two middle cylinders and each end duct to the two nearest end cylinders, the middle secondary duct being connected to the main duct at the junction of the riser with the main duct and at right angles, or substantially right angles thereto, a distributing zone with a roof having a curved portion being formed at the junction of the main duct, the riser and the middle secondary duct, the two other secondary ducts being connected to the main duct at the ends thereof, all of said secondary ducts being parallel or substantially parallel to each other and perpendicular or substantially perpendicular to the main duct on the interior, each of the end secondary ducts making a right angle connection with the main duct at the sides nearest the middle duct and the middle secondary duct making a sharp connection with the interior of the main duct, and all of said ducts and riser being devoid of curves and recesses in the direction of flow of the fuel mixture.

8. In a manifold for a six-cylinder internal combustion engine, the combination with a main manifold duct, level throughout its length, a straight or substantially straight riser duct connecting the carburetor with the central part of the main duct and being at right angles, or substantially at right angles thereto, the interior of the connection of the riser to the main duct being at a substantially uniformly sharp angle all around the connection, three secondary ducts, each for connecting the main duct to two of the engine cylinders, the middle duct with the two middle cylinders and each end duct to the two nearest end cylinders, the middle secondary duct being connected to the main duct at the junction of the riser with the main duct, and at right angles, or substantially right angles thereto, a distributing zone with a roof curved on a greater radius than the adjacent secondary duct and formed at the

junction of the main duct, the riser and the middle secondary duct, the two other secondary ducts being connected to the main duct at the ends thereof, all of said secondary ducts being parallel, or substantially parallel to each other and perpendicular or substantially perpendicular to the main duct on the interior, each of the end secondary ducts making a right angle connection with the main duct at the side nearest the middle duct and the middle secondary duct making a sharp connection with the interior of the main duct, and all of said ducts and riser being devoid of curves and recesses in the direction of flow of the fuel mixture.

FINDINGS OF FACT.

(1) The first Swan patent issued April 28, 1925, and the second, July 25, 1927; the suit on the first patent was begun in November, 1926, and upon the second patent by supplemental bill of complaint filed in September, 1927. The infringements alleged herein are for Nash manifolds made in 1925 and 1926 on Nash cars sold by defendant. In April, 1931, plaintiff brought suit against the Nash Company, and at about the same time the Reo Motor Company was sued for alleged infringements begun in January, 1927, and the Willys-Overland Company for alleged infringements begun in 1925. The Dodge Brothers Company is claimed to have infringed in 1928 but it has not been sued nor has the Chrysler Company, its successor. The present case is the only infringement suit, strictly speaking, which has been brought to trial where the validity of the Swan patents are in issue. The alleged infringements began as early as July, 1924, although technical infringement can only start with the issue of the first patent in April, 1925, and the trial of this case began in September, 1932.

(2) Substantially all of the prior art testimony offered by the defendant in this case is stipulated into this record from the record of one or the other of the *General Motors cases* hereinbefore referred to, and all of the prior art exhibited by defendant here, except defendant's Ex. 384, a Murray & Tregurtha manifold assembly, was exhibited to one or the other of the tribunals which heard and decided the *General Motors cases* hereinbefore referred to.

(3) In and about the year 1917 the gasoline furnished for the market became or was generally becom-

ing so low in volatility that manifolds for internal combustion engines were called upon to distribute wet fuel mixtures, which included particles of unvaporized or liquid fuel, from the carburetor to the several cylinders of the engine. These changing characteristics of the gasoline on the market as of about this time brought about a serious new problem, to-wit, the equal distribution of the wet or unvaporized constituents of the fuel mixture in its movement from the carburetor to the several engine cylinders. With the gasoline on the market since about 1917, the fuel mixture as it leaves the carburetor contains much liquid gasoline.

(4) The problem of distributing wet fuel mixtures from the carburetor to the several engine cylinders was complicated by the vast difference between the density and volume of the liquid gasoline as compared with the air and vaporized gas in the mixture, and further complicated by the inertia of the liquid particles and the effect of centrifugal force acting to separate the heavier liquid particles from the vastly lighter air and gas constituents of the mixture; all of which tended to distribute different quantities of mixture including the liquid constituents to the various cylinders of the engine. The complications were increasingly aggravated as the number of cylinders of the engine was increased, as for example, from three to six cylinders. This problem was difficult and its solution was long sought by many eminent and distinguished engineers throughout the automotive industry. The existence and difficulties of the problem was recognized and known to exist long before Swan entered the field. This problem demanded solution and it is conceded here that whoever solved the problem achieved much and made an important invention.

(5) No prior art manifold exhibited by defendant here effected or accomplished equal distribution of wet fuel mixtures, and no prior art manifold has the mode of operation of the Swan patented manifold and method, as described in the patents in suit. The Murray & Tregurtha prior art manifold, as operated on a three cylinder engine with automatic intake valves and with the riser and carburetor shown in defendant's Ex. 381, came nearer to getting equal distribution and operating like Swan than anything else in the prior art, but this combination of riser, header, branches and engine was different from defendant's and the patented one and was demonstrated by defendant, by the use of a header

made of glass, to fail to get equal distribution or realize the mode of operation described in the Swan Patents in suit. Defendant made no test or demonstration of the operation of any other prior art manifold or method.

(6) The island type manifold similar to plaintiff's Ex. 48 is and was a prior art manifold in extensive commercial use at and prior to the time when the first Swan application for the patents in suit was filed and the island type manifold was used on all six cylinder engines by Buick Motor Company and The Nash Motors Company when Swan or plaintiff first exhibited and demonstrated the Swan patented manifold and method to them. The island type manifold has been generally discarded since Swan's entry into the field, and was abandoned by both Buick and Nash; The Nash Motors Company changing directly from the island type manifold to the manifolds herein charged to infringe.

(7) For about seven years prior to July, 1923, both The Nash Motors Company and Buick Motor Company had used island type intake manifolds substantially like plaintiff's Ex. 48, on their six cylinder engines. During this period the engineers of The Nash Motors Company had been seeking to solve the fuel distribution problem by making improvements in the island type manifold, without departing from the general design thereof. In about July, 1923, the Buick Motor Company, acting under license from this plaintiff to General Motors Corporation, adopted the Swan manifold in its preferred form, particularly as to the cross-section of the header, and paid substantial sums in royalties to this plaintiff for the use of the Swan invention as embodied and carried out in that manifold. At about the same time, to-wit, in the summer of 1923, while The Nash Motors Company was continuing to make, use and sell the island type manifold, representatives of this plaintiff went to The Nash Motors Company and took with them and demonstrated to the Nash engineers and representatives a preferred form of the Swan patented manifold, similar to the manifold then commercially adopted by the Buick Motor Company. This manifold and others of similar construction, differing in size and "tailored" to fit various Nash engines, was demonstrated, tested and exhibited to the Nash engineers and representatives throughout the major portion of the year between July, 1923, and July, 1924. In this same period a manifold of the preferred form of the Swan patented construction

was exhibited to The Reeke-Nash Motors Company and installed on the personal car of Mr. Alfred Reeke, President of that company. Various representatives of this plaintiff spent many weeks and months during this period demonstrating, testing and exhibiting this manifold to The Nash Motors Company, its representatives and engineers. Many comparative tests were made between the Swan patented manifold and the island type manifold in the presence of plaintiff's representatives and the representatives of The Nash Motors Company. These tests included laboratory tests and various and extensive road tests, comprising such standard and accepted tests as acceleration, hill climbing, economy and general performance. The Swan patented manifold in its preferred form, as tested and exhibited in this period, was demonstrated to be a substantial and distinct improvement over the island type manifold.

(8) In about July, 1924, Buick Motor Company modified its intake manifold construction from the square preferred form of Swan's manifold to a rounded form like plaintiff's Exs. 6, 7, 9 and 10 here. At almost exactly the same time The Nash Motors Company abandoned the island type manifold, to which it never returned, and adopted on all of its six cylinder engines manifolds like plaintiff's Exs. 45, 45A, 46 and 46A. All of these manifolds, both Buick and Nash, embodied curved or partly curved recessed roofs or domes in the header opposite the riser. Later the Buick Motor Company again modified its construction by eliminating the recessed portion of the roof of the header, plaintiff's Exs. 8 and 11, and at about the same time The Nash Motors Company also modified its manifold construction in substantially the same way. (See plaintiff's Exs. 40, 43, 43A and 44.) In both the first and second *General Motors cases* the Buick manifolds, plaintiff's Exs. 6 to 11 inclusive, were held to come within the license contract between this plaintiff and General Motors Corporation, by virtue of the findings in both of those cases that such manifolds were the equivalent of the square or preferred form of the Swan patented manifold, and all of such manifolds embodied and carried out the Swan invention as disclosed in the original Swan application and as disclosed and claimed in such of the Swan patents in suit here as were before the tribunals which heard and decided those cases, and that all of those Buick manifolds were covered by some or all of the claims of at least patent No. 1,536,044 here in suit.

(9) There has been extensive litigation involving the Swan patents in suit and the inventions disclosed and claimed therein, and the claims or some of them of the patent No. 1,536,044 in suit have been sought by others by interference proceedings in the United States Patent Office.

(10) The Swan patented manifold as described and claimed in the patents in suit has gone into extensive commercial use, both in the square or preferred form and in the round and hexagonal form, and many licenses under the patents in suit have been granted by plaintiff to various automobile manufacturers and engine manufacturers. The several licensees having license under the patents in suit voluntarily paid royalties on more than 800,000 manifolds, including those of square cross-section, according to the preferred form of the patented manifold, as well as manifolds of rounded and hexagonal cross-section. In the first *General Motors case,* to which reference has previously been made, royalties were paid by judgment of the United States District Court for the Northern District of Ohio on more than 500,000 manifolds manufactured and sold by the Buick Motor Company, plaintiff's Exs. 9, 10 and 11 here.

(11) The method invented by John W. Swan and patented in patent No. 1,536,044 in suit was based upon a new and original principle of operation, was disclosed in the original Swan application, Serial No. 501,314, or was so sufficiently set forth or suggested in that application as to constitute a sufficient basis for amendment to support the method claims 4, 5, 8, 9 and 10 of said patent. The said method described in said patent and applications and claimed in the claims of said patent, is carried out and practiced in the preferred form of the Swan patented manifold and in equivalent forms made in accordance with the disclosure and teaching of the patents in suit. Among the results achieved by the practice of the Swan patented method, there is realized an equal or substantially equal distribution of fuel mixture, including the liquid particles or constituents of the mixture, to the several engine cylinders along with other and resultant advantages.

(12) Each of defendant's manifolds here charged to infringe, illustrated in plaintiff's Exs. 40 to 46 inclusive and 50, when mounted upon and operated with internal combustion engines such as the Nash engines, with which such manifolds were operated, embody the

aforesaid new and original principle of operation introduced by Swan and accomplished and carry out the said Swan patented method of fuel distribution in the manner taught in the patents in suit and as defined and claimed in claims 4, 5, 8, 9 and 10 of the Swan patent No. 1,536,044 in suit. In each of said defendant's manifolds there is realized and achieved or substantially realized and achieved the results and advantages peculiar to the Swan patented method including the result of equal or substantially equal fuel distribution. If any differences exist between the method employed in any of defendant's manifolds here charged to infringe and the patented method, such differences are merely a matter of degree and are immaterial.

(13) Nowhere does the prior art, exhibited by defendant here, realize, disclose, or recognize the Swan patented method disclosed and claimed in patent No. 1,536,044 in suit or as practiced or carried out in defendant's manifolds here charged to infringe or any of them. No method is disclosed, taught, or recognized in the prior art which limits or restricts the method, claimed in claims Nos. 4, 5, 8, 9 and 10 of patent No. 1,536,044 in suit, in any manner whereby the method carried out and practiced in each and all of defendant's manifolds is not covered by each and all of said claims. No document in the prior art discloses the Swan patented method or discloses any method for obtaining the results and advantages accomplished by the Swan patented method and by defendant with its manifolds here charged to infringe. Swan is a pioneer in the patented method for distributing wet fuel mixtures as distinguished from dry mixtures and nowhere does the prior art show any recognition or realization of the solution of this problem which Swan solved by his patented method.

(14) Nothing in the prior art restricts the Swan patented method as claimed in claims 4, 5, 8, 9 and 10 of patent No. 1,536,044 in suit to a manifold of square or rectangular cross-section as a means of accomplishment, as distinguished from a manifold of round or circular cross-section. Nothing in defendant's adoption of round construction, like the manifolds here charged to infringe or any of them, makes or causes the method carried out in such round manifolds conform to or embrace any prior method recognized, disclosed, or realized in the prior art.

(15) Nothing in the prior art restricts the Swan patented method as claimed in claims 4, 5, 8, 9 and 10 of

patent No. 1,536,044 in suit to a manifold having sharp right angled inside corners or flat walls at the ends of the header, or a flat wall opposite the riser, as a means of accomplishment, as distinguished from slightly rounded inside corners or curved walls at the ends of the header, or a curved or partially curved wall opposite the riser as found in some or all of defendant's manifolds here charged to infringe; and nothing in defendant's adoption of the manifolds having rounded inside corners or curved or partially curved walls, as found in defendant's manifolds here charged to infringe, so modifies or changes the method carried out in such manifolds or any of them as to make that method conform to or embrace any prior method recognized or disclosed in the prior art, or to so depart or differ from the Swan patented method as to exclude the method carried out in defendant's manifolds from the patented method claims relied upon by plaintiff herein.

(16) The prior art, as it is exhibited by defendant here for the purpose of showing or attempting to show any method or process of distributing fuel mixture to an internal combustion engine, is the same or substantially the same as that which was exhibited in one or the other of the cases of the *Swan Carburetor Company v. The General Motors Corporation* hereinbefore referred to, and nothing here exhibited as to any prior method is more pertinent to the Swan patented method or more fully disclosed as ever having existed than were the method or methods, if any, employed in the prior art manifolds, which were offered and received in evidence in both of the said preceding cases involving the Swan patents and inventions.

(17) The manifold apparatus and combinations invented by John W. Swan and patented in the patents in suit were based upon a new and original principle of operation, were disclosed in the original Swan application, Serial No. 501,314, and described therein as to structure, function and mode of operation, or so sufficiently set forth or suggested in preferred and modified forms in that application as to constitute a sufficient basis for amendment to support claims 11, 12, 13, 20, 22 and 23 of patent No. 1,536,044 in suit and claims 5, 7 and 8 of patent No. 1,636,721 in suit. The manifold apparatus and combinations described in the patents in suit and in the applications upon which said patents issued and claimed in the claims upon which plaintiff here relies, as enumer-

ated above, and embodying the Swan improvements patented thereby, obtain distinctive and advantageous results including, among other things, equal distribution of fuel mixture and the liquid particles and constituents thereof to the several engine cylinders, and particularly to the several cylinders of six cylinder engines, and operate as described in the patents in suit and function according to the teaching of the patents in suit.

(18) Each and all of defendant's manifolds charged to infringe, as shown in plaintiff's Exs. 40 to 46 inclusive and 50, are so identical or so substantially identical in structure, function, mode of operation and results to the Swan patented manifold as defined in some or all of the claims upon which plaintiff here relies, that when operated as they are operated and used upon or in combination with defendant's engines, they perform the same or substantially the same function, have the same or substantially the same mode of operation, and achieve the same or substantially the same results as do the Swan patented manifolds, as described in the patents in suit and claimed in some or all of the said claims here relied upon by plaintiff. Such differences in structure, as may be found to exist in one or more of defendant's manifolds as compared with the preferred form of the patented manifold by reason of defendant's use of round construction as distinguished from square construction, or by reason of defendant's use of slightly rounded inside corners instead of sharp right angle inside corners, or by reason of defendant's use of curved or partly curved walls at the ends of the header and opposite the riser, are immaterial in that such departures as defendant has made in the structure of its manifolds, here charged to infringe, do not effect any substantial or material difference in function, mode of operation, or results in such manifolds as compared with the patented manifolds or the preferred form of the patented manifolds, and such differences as may be found are immaterial in that the effect of such changes and the extent of such differences are merely in matter of degree and are not differences in kind or substance.

(19) The prior art manifolds, here exhibited by defendant, are the same or substantially the same as were exhibited to the tribunals that heard and decided the actions brought by this plaintiff against the General Motors Corporation hereinbefore referred to. Nothing exhibited by defendants here is more pertinent to the

patented manifold apparatus or combination or to the manifold apparatus or combination employed by defendant than were the prior art manifolds exhibited in the preceding litigation.

(20) Defendant has produced no documentary evidence that any prior art device operated like or according to the Swan principle of operation, or performed the function, had the mode of operation or achieved the results of the Swan patented manifold, or defendant's manifolds here charged to infringe. None of the prior art manifolds exhibited by defendant here have the structure, function, mode of operation, or results of the Swan patented manifold apparatus or combination or defendant's manifold apparatus or combinations here charged to infringe.

(21) Nothing in the prior art restricts the claims of the patents in suit heretofore enumerated, which define the apparatus or combination of elements patented therein to the preferred form of Swan's patented manifold with square or rectangular cross-section or with sharp right angled inside corners or with flat walls opposite the riser and at the ends of the header, and nothing in defendant's adoption of the manifolds here charged to infringe of round cross-section with slightly rounded inside corners and wholly or partly rounded walls opposite the riser and at the ends of the header, is in such accordance with any prior art manifold or the teaching of any prior art patent or publication or is in such accordance with any prior art construction with respect to function, mode of operation, or results that any of defendant's manifolds can be said to fairly differentiate from the patented construction or combination, or can be said to be made in accordance with or in substantial accordance with any manifold or complete combination shown to have existed in the prior art.

(22) Nowhere does it appear in the current state of the art relating to manifolds or methods of fuel distribution that anyone has brought forward a solution to the problem of fuel distribution or improved upon Swan's solution by any means not based on the Swan principle of operation. The adoption and use of the Swan patented manifold and method by licensees, paying royalties to this plaintiff, has increased and is increasing in proportion to all other manifolds made, used and sold in the whole automobile industry, including those manifolds charged to infringe in this and other suits brought by this plaintiff.

(23) At no time in the prosecution of either of the Swan applications Serial Nos. 501,314 and 747,991, or in the filing of application Serial No. 747,991, upon which the patents in suit matured, did Swan surrender anything or acquiesce in any limitation as a condition to the grant of the claims in the patents in suit whereby to exclude from the scope and effect of the claims, here relied upon by plaintiff, the manifolds or methods or any of them employed by defendant, and here charged to infringe. Such amendments as were made in the original Swan application Serial No. 501,314, either directly in that application or in or by virtue of the filing of the second Swan application Serial No. 747,991, were only in amplification and explanation of what was already reasonably indicated to be within the invention originally disclosed and described in the said original application, and said amendments indicated that Swan came to better understanding of the principles of his invention or inventions while his application or applications for the patents in suit were pending, and that he did no more than make his claims conform to and express his better and fuller understanding of the principles of his invention. The tribunals before whom the Swan invention or improvements and applications and patents were previously considered also considered the proceedings taken by Swan in the Patent Office, and the amendments therein made to the applications for the said patents in suit.

(24) In the testimony stipulated into this record from the record of the first *General Motors case* of the testimony taken before Judge Westenhaver, plaintiff has adduced evidence here as to the method, function, operation and results carried out and achieved in the preferred form of the Swan patented manifold of square cross-section, plaintiff's Ex. 16, and a Buick manifold of round cross-section, plaintiff's Ex. 15, as measured by gas analysis tests, which tests demonstrated equal or substantially equal distribution of the fuel mixture including the liquid constituents thereof to each of the several engine cylinders of the six cylinder engine upon which the tests were made. Those tests were made *inter parte* in the trial of the first *General Motors case* and the testimony and exhibits concerning them were offered and received in evidence here without objection as to their being made *ex parte* to this proceeding.

In the instant case, plaintiff has made numerous road tests under actual driving conditions comparing one of

defendant's manifolds here charged to infringe, plaintiff's Ex. 42A, with a preferred form of the Swan patented manifold, plaintiff's Ex. 42B, and with a manifold similar to one of the Buick manifolds for which royalties were awarded by judgment in the first *General Motors case*, plaintiff's Ex. 42C. In these tests the performance and operation of the manifolds when mounted on a Nash six-cylinder automobile engine were compared in hill climbing, acceleration, fuel economy and general performance. The results of these tests showed that the three manifolds carried out the same or substantially the same method, operated in the same or substantially the same way, and achieved the same or substantially the same results, including equal or substantially equal distribution of the fuel mixture.

The gas analysis tests made of record here by plaintiff are tests made to determine the performance of the individual engine cylinders with particular respect to the combustion therein, the products of combustion exhausted therefrom, and the equality or lack of equality of the fuel distribution effected by the intake manifold. Gas analysis tests are and were well known and generally accepted and practiced in the industry, and are and have been used by many automobile and internal combustion engine manufacturers for many years, including a period of time prior to the trial of the first *General Motors case*. The road tests of the kind and character performed by plaintiff here in the presence of the Master are universally used and accepted throughout the entire automotive industry for comparing and determining the performance, operation, results and achievements of intake manifolds. Road tests of the character made by plaintiff here are similar in kind to those made and relied upon by defendant in the first *General Motors case*.

Plaintiff's demonstration to the Master, under starting and actual road conditions such as hill climbing and acceleration, of a preferred form of the Swan patented manifold, plaintiff's Ex. 42D, having large glass windows in the roof and floor of the header and also opposite the riser outlet, wherein the appearance of the contents of the manifold was observed during the actual operation of the car, showed that the movements of the fuel mixture, including the liquid particles, were in substantial accordance with the disclosure and description of the function and mode of operation of the patented manifold and method, as set forth in the patents in suit and the application thereof.

(25) The Master finds that the plaintiff's demonstrations and tests have all been of the kind and character long accepted and universally adopted by the automotive industry as a whole for the purpose of determining the operation, performance and results of intake manifolds for and methods of fuel distribution to internal combustion engines, and have been previously accepted as standard and reliable tests by the tribunals which have previously heard and decided similar questions and issues concerning the inventions and patents in suit. All of plaintiff's tests, witnessed by the Master, were made on engines operating under their own power under normal driving and operating conditions with normal commercial manifolds and with fuel mixture ratios such as are commonly used in actual service operation. All of the road tests, including the visual tests or observations, were made on a car operating on the road under its own power with all conditions normal throughout such operation.

(26) The Master finds that the tests made by defendant were new and consisted of laboratory tests only and showed the operation of forces and influences on the fuel mixtures, the actions of which were theretofore unknown to Swan, the patentee, or his expert counsel. This apparatus in the laboratory consisted of the manifold, defendant's Ex. 375, having transparent walls, operated with stroboscope demonstrations, with Neon lights, and following the tests moving pictures of the tests at different speeds were shown on the Court Room.

(27) The Cox indicator is an instrument which has been in successful commercial use for automatically measuring and recording the pressures in the different cylinders of a gasoline engine, and was used in the tests in this case known as the Fulwiler and Detroit tests. By the use of this indicator, where the only variable is the mixture ratio, there is shown a changing of the mixture charge and how the manifold distributed such mixture, and in said tests differences in the effect of the manifold on distribution are shown, that is to say, such indicator registers the character of the mixtures as delivered to each cylinder separately, which seems to be an improvement over the gas analysis tests offered by plaintiff in this case.

(28) The road tests made by plaintiff in this case, while having the sanction of the trade by long usage, did not test the character of the mixtures delivered to the different cylinders of the engine.

(29) The preferred "Swan method" as described in the patents is as follows: that at each successive cylinder aspiration, a uniform atomized mixture of air, gasoline vapor and liquid particles moves up the riser in straight lines, without swirling and without depositing liquid on the riser walls. The mixture strikes the flat ceiling of the header directly above the riser and at right angles to its direction of movement. From this surface the mixture rebounds and spatters, thereby creating "turbulence." The horizontal flatness, i.e., symmetry, of the ceiling with relation to the three outlets from the T, causes the impinging, the rebounding and the spattering not to favor, or deflect the mixture to, one outlet from the T rather than to another. The mixture "makes an abrupt right angle turn." When a center cylinder aspirates, the uniform mixture flows out through the center outlet. When an end cylinder aspirates, the mixture moves through the header in straight lines, impinges on the flat wall at the end of the header, rebounds and spatters and then moves into the end outlet. There are no accumulations of liquid in the manifold, and accumulations of liquid would militate against the carrying out of the method.

(30) The assembly, consisting of a Nash six-cylinder engine, a Swan square section manifold and a Marvel equipment comprising a riser containing the usual butterfly throttle, an exhaust gas jacket on the riser and a Marvel carburetor, is the typical assembly involved in this case; and this has been used in many of the tests made by the parties herein and may be called a Nash-Swan-Marvel assembly. The firing order of the cylinders of the Nash engine of the Nash-Swan-Marvel assembly is 1-5-3-6-2-4.

(31) Observing and considering the tests and demonstrations made by both parties, the Master finds that the Swan patented manifold in its preferred and equivalent forms, and each and all of defendant's manifolds here charged to infringe, function, operate and carry out the Swan patented method in accordance with or substantial accordance with the teaching, description and disclosure in the patents in suit; and that Swan patented manifold in its preferred and equivalent forms, along with each and all of defendant's manifolds here charged to infringe, and the Swan patented method carried out with each of said manifolds, accomplish the results and advantages described and disclosed in the

patents in suit, including the result of equal or substantial distribution of the fuel mixture, including the particles of liquid gasoline contained therein, to the several engine cylinders.

(32) The island type of manifold which preceded the Swan manifold, and with which Swan was compared by some, was inferior to the Swan manifold, that is to say, the Swan manifold was an improvement upon any of the island manifolds which was the highest development of manifolds before the appearance of the Swan manifold.

(33) The principle of operation of the Swan patented manifold in its preferred form of square or rectangular cross-section is the same as in defendant's manifolds here charged to infringe of round cross-section. The operation of the manifolds is the same whether they be round or square in cross-section.

(34) The abnormalities claimed by plaintiff in the construction of the manifolds (defendant's Exs. 325 and 375) used in the tests, being (1) a construction different at one end than at the other; (2) a fin found in the manifold (Ex. 375) unknown to defendant; and (3) a thermocouple claimed as an obstruction in the path of the mixture stream, had no appreciable effect upon the movement of the mixture, and were not of sufficient effect to materially change the results of the tests.

(35) Various members of the National Automobile Chamber of Commerce have published or caused to be published advertisements proclaiming the utility and efficiency of the Swan patented manifold, and proclaiming that the Swan patented manifold achieved many distinctive advantages and results as evidenced by engine operation and car performance, and also achieved the novel, useful and distinctive advantage or result of affecting equal distribution of the fuel mixtures to the several engine cylinders of the internal combustion engines with which they were employed and used by said members. A great number of eminent and experienced engineers, who at first were doubtful and skeptical, later, after experimenting with the Swan patented manifold and method in operation with internal combustion engines under many and varied road and laboratory conditions in the usual course of their employment with various members of the National Automobile Chamber of Commerce, came to praise the Swan inventions or improvements and ad-

mit the utility and excellence of the Swan patented manifold and method, and proclaim the achievements and performance thereof, including the achievement of equal or substantially equal distribution of the fuel mixture to the several engine cylinders.

(36) The National Automobile Chamber of Commerce is conducting the defense of this suit and its directors, acting on behalf of the Chamber, selected counsel and are paying the expenses of the suit. All of the members of the National Automobile Chamber of Commerce (see plaintiff's Exs. 57, 58, Stipulation Ex. 74 and Ex. 144) have contributed and are contributing to the expenses of this litigation according to an agreed system or systems. Among said members, The Nash Motors Company, Reo Motor Car Company, Willys-Overland Company, Chrysler Corporation, Plymouth Motor Corporation and Graham Paige Motors Corporation, paid their share of all the expenses of the said National Automobile Chamber of Commerce, including the expense of this litigation.

(37) On or about June 19, 1925, plaintiff, The Swan Carburetor Company, served due and formal notice of infringement in writing, plaintiff's Ex. 47, upon defendant, The Nash Motors Company, by registered mail, directed to the attention of Mr. C. W. Nash, then President, and the same was received in the usual course of mail on or about the day following. Long prior to the writing of this formal notice of infringement, and long prior to the date of issuance of the patent No. 1,536,044 in suit, plaintiff through its representatives had advised the defendant, The Nash Motors Company, that it was seeking Letters Patent of the United States covering and protecting the Swan patented manifold and method as exhibited to The Nash Motors Company as early as the summer of 1923, and plaintiff by its President had long prior to the issuance of patent No. 1,536,044 entered into negotiations with Mr. C. W. Nash, President of The Nash Motors Company, to arrange a license for the manufacture, use and sale of manifolds embodying or carrying out the Swan inventions now patented in the patents in suit, and quoted to Mr. Nash the standard license or royalty rates obtained for such a license and expected from The Nash Motors Company in the event it made, used or sold manifolds embodying or carrying out said Swan invention or inventions under license from this plaintiff.

CONCLUSIONS OF LAW.

(1) That the United States District Court for the Northern District of Ohio, Eastern Division, in which this suit was brought, has jurisdiction over subject matter of and parties to this suit.

(2) That the Swan patents in suit, Nos. 1,536,044 and 1,636,721, and each of them are valid and describe, disclose and claim in claims 4, 5, 8, 9, 10, 11, 12, 13, 20, 22 and 23 of patent No. 1,536,044 and in claims 5, 7 and 8 of patent No. 1,636,721 new and useful inventions or improvements in intake manifolds for internal combustion engines and methods and means to facilitate the distribution of fuel mixture in internal combustion engines.

(3) That the patent in suit, No. 1,536,044, is a basic patent and defines and covers a pioneer invention or inventions, and is entitled to a liberal interpretation and a broad range of equivalents.

(4) That the patent in suit, No. 1,636,721, as to claims 5, 7 and 8, is subsidiary in rank to patent No. 1,536,044 and defines and covers a meritorious improvement and is entitled to a liberal interpretation and a substantial range of equivalents consistent with its rank and relation to patent No. 1,536,044.

(5) That the method or methods of distributing fuel mixture practiced and carried out in each and all of defendant's manifolds here charged to infringe, illustrated in plaintiff's exhibits 40 to 46 inclusive and 50, when operated with the internal combustion engines for which said manifolds were made and with which said manifolds were used and sold is and was covered by claims 4, 5, 8, 9 and 10 of patent No. 1,536,044 in suit, and the practice of said method by the use of said manifolds on said engines constitutes and constituted an infringement of said patent with respect to said claims. The defendant, The Reeke-Nash Motors Company, aided and abetted by The Nash Motors Company, the other of the defendants named and identified in the original and supplemental Bills of Complaint, infringed the said patent and contributed to the infringement thereof with respect to said method claims as and in the manner alleged in the Bill of Complaint.

(6) That each and all of defendant's manifolds here charged to infringe illustrated in the drawings, plaintiff's exhibits 40 to 46 inclusive and 50, as an apparatus or a combination with or for the internal combustion

engines for which said manifolds were made, and with which said manifolds were used and sold, are covered by claims 20, 22 and 23 of patent No. 1,536,044 in suit; the manifold illustrated as to header and branches in plaintiff's exhibit 41 is also covered by claims 11, 12 and 13 of patent No. 1,536,044 in suit; the manifolds illustrated in plaintiff's exhibits 40 and 43 are also covered by claims 5, 7 and 8 of patent No. 1,636,721 in suit; the manifold illustrated as to header and branches in plaintiff's exhibits 42, 45 and 46 are also covered by claims 7 and 8 of patent No. 1,636,721 in suit; the manifold illustrated as to header and branches in plaintiff's exhibit 44 is also covered by claims 5 and 7 of patent No. 1,636,721 in suit.

(7) That the defendant, The Reeke-Nash Motors Company, aided and abetted by The Nash Motors Company, the other of the defendants, named and identified in the original and supplemental Bills of Complaint, infringed and contributed to the infringement of said patents in suit with respect to the apparatus and combination claims as herein respectively designated and as and in the manner alleged in the Bill of Complaint and the Supplemental Bill of Complaint.

(8) That the defendant here having appropriated the distinctive features and characteristics of the Swan patented inventions are estopped from denying the utility thereof, and apart from such estoppel the defense did not carry the burden by law imposed upon it to show lack of utility in the patented inventions or to show inoperativeness of the patents in suit or to show any material or substantial difference between the mode of operation of the patented inventions described in the patents in suit and actually carried out and embodied in the methods and manifolds disclosed in the said patents and in defendant's infringing methods and manifolds.

(9) That matter was not inserted in the applications upon which the patents in suit matured or either of them by way of amendment or otherwise, which causes any cloud upon the validity or scope of the patents in suit or either of them.

(10) That plaintiff is not estopped by reason of any proceedings in the Patent Office in connection with the prosecution of the patents in suit from asserting the claims of the patents in suit, here relied upon, with the

full range of equivalents to which they are on their face entitled in view of the state of the prior art.

(11) The various members of the National Automobile Chamber of Commerce (plaintiff's Exs. 57 and 58) are privies to the defendant in this suit, and statements made by such members or by their engineers or representatives, acting in the usual course of their employment, are admissible in evidence here as admissions against interest made by privies of this defendant.

(12) That the plaintiff is entitled to the relief prayed for in the Bill of Complaint and Supplemental Bill of Complaint and every part thereof as against the defendant, The Reeke-Nash Motors Company.

(13) That the plaintiff have and recover the costs of this suit.

MEMORANDUM.

The validity of the Swan patents was not an issue in the *General Motors* cases, those suits being upon the license, by the owner of the patents against its licensee. The efforts of defendant were there confined to establishing and restricting the limits of the patents, while in the case at bar defendant contests the validity of the patents themselves.

While the decision in the *General Motors* case is not binding here as to the validity of the patent, comity at least requires that most serious consideration be given to the prior findings of the courts which have considered these patents.

PRESUMPTION OF VALIDITY.

At the outset the Swan method of manifolding is denied patentability by defendant Reeke-Nash Company on two grounds: (1) that what Swan sought to patent was not patentable; and (2) that he incorrectly described or failed to describe what he sought to patent.

The assumption must be that the claims of the patents are valid until the contrary is shown. The validity of the patent is presumed, and this presumption implies patentable novelty and utility. *Westinghouse v. Formica*, 266 U. S. 342, 348 (1924); as to novelty, *Soderman Heat & Power Co. v. Kaufman*, 14 Fed. (2) 392, 394 (CA 8, 1926), and as to utility, *Boyce v. Stewart-Warner Co.*, 220 Fed. 118, 126 (CCA 2, 1914). We therefore start with the assumption that the claims in issue describing

the steps in the method and the apparatus are valid over the prior art.

This presumption of validity is rebuttable and the question of validity is not to be confused with the question of the scope to be given the claims with which we are principally concerned, if the claims are found to be valid, and the question of infringement of defendant's devices then remains for determination.

PATENT CLAIMS FOR A METHOD OR PROCESS.

The method claims in issue of the first Swan patent are Nos. 4, 5, 8, 9 and 10, and it will suffice to quote claim 4 as typical of these method claims:

> "4. A method of distributing a fuel mixture to an engine which consists in moving the mixture in a straight line to a zone from which it is distributed to a plurality of engine cylinders, directing said movement by forces which tend to distribute the mixture uniformly in all directions in a plane transverse to said movement, and further directing the movement of the mixture by forces tending to move it successively in a plurality of directions transverse to the original direction, to the cylinders."

The first step of this method is "moving the mixture in a straight line to a zone," namely, the T zone or so-called distributing zone of the riser. Defendant claims the mixture does not move in a straight line in the riser to this zone, but on the contrary moves in a turbulent, swirling spiral, being deflected by the carburetor intake and jets and by the angularity of the throttle.

The next step of the method takes place at "the distributing zone," and is "directing said movement by forces which tend to distribute the mixture uniformly in all directions in a plane transverse to said movements." By Swan's theory the forces act upon the mixture at the T and distribute it uniformly in the front and rear header branches and into the center outlet. Defendant claims that there are no such forces but that the forces which do act on the mixture at the T do not have a uniform effect.

The Swan theory is that the mixture is a homogeneous mixture of air, vapor and liquid particles which move up the riser in straight lines, which theory defendant asserts is wholly fictitious and imaginary.

Defendants further claim that the forces operating in the manifold cause an unequal distribution of the

liquid mixture in the manifold; that they enrich the end cylinders as compared with the center cylinders, that they enrich the inside cylinder of each end pair, and thus cause errors of unequal distribution which defendants have sought to demonstrate by showing an unequal performance of the different cylinders. The defense is grounded on the proposition that the claim is invalid because the method claimed by Swan is not performed by the Swan manifold.

The rule as to patents for a method or process is stated in *Walker on Patents,* 6th Ed., Sec. 160. "It is not essential that an inventor should understand or set forth the scientific principle upon which his invention works." A process has been defined as a mode of treatment of certain materials to produce a given result. This rule was early laid down by Mr. Justice Bradley in *Cochrane v. Deener,* 94 U. S. 780 (1876), where he said at p. 788:

> "A process is a mode of treatment of certain materials to produce a given result. It is an act, or a series of acts, performed upon the subject-matter to be transformed and reduced to a different state or thing. If new and useful, it is just as patentable as is a piece of machinery. In the language of the patent law, it is an art. The machinery pointed out as suitable to perform the process may or may not be new or patentable; whilst the process itself may be altogether new, and produce an entirely new result. The process requires that certain things should be done with certain substances, and in a certain order; but the tools to be used in doing this may be of a secondary consequence."

Where a claim for a method or process not involving chemical change or change of substance, was held valid and patentable, and asserted the validity of a process having to do with hydrodynamics and simply dealing with the flow and control of fluids, Mr. Justice Blatchford in *New Process Fermentation Co. v. Maus,* 122 U. S. 413 (1887) said at p. 427:

> "Within the rules laid down by this court in *Corning v. Burden,* 15 How. 252, 267, in *Cochrane v. Deener,* 94 U. S. 780, 787, 788, and in *Tilghman v. Proctor,* 102 U. S. 707, 722, 724, 725, we think that the method or art covered by the third claim of the patent is patentable as a process, irrespective of the apparatus or instrumentality for carrying it out."

A process patent was held valid for the dominant pool for the Bessemer Furnace in *Carnegie Steel Co. v. Cambria Iron Co.,* 185 U. S. 403 (1902). The specification sought "to provide means for rendering the product of steel works uniform in chemical composition * * *" (p. 443), and as to this, the court said: "If it be true that this process cannot be carried on without infringing the Jones patent, he is certainly entitled to a monopoly of the invention."

In this circuit a patent for method of feeding water to boilers, based on the theory of retarding the lag and maintaining a variable constant, was held valid. *Northern Equipment Co. v. McDonough Automatic Regulator Co.,* 300 Fed. 488 (1924), on page 491 Judge Denison says:

> "If anyone before Andrews both observed and intelligently appreciated the factors involved in the variable constant theory and worked out his ideas into concrete form, it is not disclosed by this record, as we understand and interpret the testimony. Such prior appreciation of the theory as there was, if any, was vague and abstract,"

and comments upon the method claim in suit, page 492. Again in the purolator case, *Motor Improvement Co. v. General Motors,* 49 Fed. (2) 543 (1931), the Court of Appeals of the 6th Circuit held the Sweetland patent, relating to oil filters, valid and infringed, and considered the method or process claims in its opinion.

In the recent case of *Nestle-Le Mur Co. v. Eugene,* 55 Fed. (2) 854 (1932), was involved a patent of machine claims for permanently waving hair, but there were no method or process claims involved in the suit. While the Court of Appeals reversed the District Court, Judge Hickenlooper goes on to state that process claims might have been valid, but such had not been made. The machine claims were invalid since they involved only the arrangement of old electrical apparatus which could be manipulated by any mechanic skilled in the art. The Judge quoted from *Cochrane v. Deener, supra,* and says at p. 857:

> "The subjects covered by patents for a process and for a machine, although frequently related and in sense often founded upon the same mental concept, are nevertheless in substance independent and radically different. As clearly stated in the authorities here cited, 'a machine is a thing,' while 'a

process is an act, or a mode of acting'; 'a new process is usually the result of a discovery; a machine, of invention.' "

HOW ACCURATELY NEED A PATENTEE DESCRIBE HIS DISCOVERY OR INVENTION?

Since it is established that a method or process is patentable, the question arises, how accurately must a patentee describe his discovery or invention. In the case at bar a method or process is involved, so following the authorities as pointed out by Judge Hickenlooper, the question here is, how accurately was Swan required to describe his discovery.

Walker on Patents states the rule "it is not essential that an inventor should either understand or set forth the scientific principle on which his invention works," 6th Ed., Sec. 160.

In his first application Swan stated "I have found it somewhat difficult to analyze the exact theory on which my discovery rests. * * *" Question then arises, if the method claimed by Swan is not an accurate description of what actually happens in the manifold, is his patent defeated and invalid. This brings us to a consideration of the rules as to how far courts will go in destroying a patent on the grounds that the inventor failed to sufficiently describe the forces which enter into the operation of his method or process.

Early in the administration of Patent Law the Supreme Court held in the *Telephone* cases, 126 U. S. 1 (1888) in the 2nd Syllabus: "In order to procure a patent for a process, the inventor must describe his invention with sufficient clearness * * * and must point out some practicable way of putting it into operation; but he is not required to bring it to the highest degree of perfection."

In this Circuit this question was raised in connection with the Jeavons Oil Burner, reported in *Cleveland Foundry Co. v. Detroit Vapor Stove Co.*, 131 Fed. 853 (1904) where defendant sought to destroy the patent by asserting that the inventor did not describe with sufficient definiteness the forces which entered into the operation of the Jeavons Burner. In that case Judge Severens said, at p. 855:

"A burner made according to their construction would operate in the way to be expected from the

claim. * * * But he (Jeavons) did see and know that the burner he had devised would successfully accomplish the results he anticipated and was laboring for. * * * But the fact is that, by constructing the burner in the manner prescribed by him, (Jeavons) the vapor is produced and distributed to and in the combustion chamber in a very satisfactory and useful way. That it is a successful improvement on all former methods is shown by the general adoption of it by the public, no less than 122,000 burners of this kind having been sold within 2½ years. It may be that the patentee did not fully understand the rationale of the manner in which his construction effected the results, and it may be that expert witnesses have not in all respects correctly apprehended it. But if the fact be that his construction does effect the results and they are beneficial, he is none the less entitled to the benefit of his invention though he may not have correctly understood the principles of its operation. *Andrews v. Cross,* 19 Blatchf. 294, approved in the *Driven Well* case, *Eames v. Andrews,* 122 U. S. 40, 55 (1887)."

Many forces, such as the force of gravity, centrifugal force and inertia, act and persist and are understood by those skilled in the arts. The rule is summarized by the Supreme Court in *Diamond Rubber v. Consolidated Tire,* 220 U. S. 428 (1911) which involves rubber tires, where Mr. Justice McKenna says, at p. 435:

"And how can it take from his merit that he may not know all of the forces which he has brought into operation? It is certainly not necessary that he understand or be able to state the scientific principles underlying his invention, and it is immaterial whether he can stand a successful examination as to the speculative ideas involved. (Citing the *Driven Well* case, *supra, Cleveland Foundry Co. v. Detroit Vapor Stove Co., supra,* and others.) He must indeed make such disclosure and description of his invention that it may be put into practice."

Mr. Chief Justice Taft expressed the same thought when he said, in *Eibel Process Co. v. M. & O. Paper Co.,* 261 U. S. 45 (1923) at p. 63:

"Infringement exists if the claim fairly reads upon the defendant's device which may not be exactly the one described and if it approximates it nearly

enough so that it may be said to be an equivalent thereof. The range of equivalency is to be determined in the light of the state of the art and the advancement made therein."

Thus specifications and claims are addressed to those skilled in the art and a claim should be liberally construed. *Sun Ray Gas Corp. v. Bellows-Claude Neon Co.*, 49 Fed. (2) 886 (C. C. A. 6, 1931). In the recent case of *National Battery Co. v. Richardson Co.*, 63 Fed. (2) 289 (1933), the Court of Appeals of the 6th Circuit, in the 3rd Syllabus says that "where the inventor had mental concept of a new composition of matter to achieve a desired result * * * the invention consisting of the mental concept." While this patent was for a composition on the questions of the sufficiency of the disclosure and that patents are addressed to those skilled in the art, Judge Hickenlooper says, at p. 293:

> "The specifications and claims are addressed to those skilled in the art * * * that which is, and was understood to be, necessary to make the claim operative may then be implied therein, provided always, that the description of the claim and the specification is sufficient to enable one skilled in the art, with the specifications and claims before him, and without the necessity of further experiment itself of an inventive nature, to practice the invention of the patent."

DID SWAN SHOW ANYTHING NEW, AND IF SO, WAS THIS INVENTION?

Often it is difficult to determine whether invention exists in an apparatus or method which is essentially an improvement upon the prior art devices or means for securing similar results. There seem to be no sure tests which can be applied in all cases.

The question is one of fact to be determined by the weighing of evidence in the light of decisions of the courts upon analogous states of facts where rules have been declared which seem to be applicable.

Attention has been called to the recent case of *Newcomb, David Co., Inc. v. The R. E. Mahon Co.*, 59 Fed. (2) 899 (1932), where the Court of Appeals of this Circuit held that invention does not exist in merely aggregating or "making judicious selection from" the devices of the prior art, each designed and utilized to accomplish

its individual purpose at a time and in a place where such function is necessary for the operation of the whole, and Judge Hickenlooper said, p. 901:

> "This is but the exercise of the mechanical ability reasonably to be expected in the development of the art, and has repeatedly been held insufficient to evidence invention, whether such decision be placed upon the ground of aggregation or upon the lack of an exercise of the inventive faculty. *Concrete Appliances Co. v. Gomery*, 269 U. S. 177. * * * And compare: *Sachs v. Hartford Electric Supply Co.*, 47 Fed. (2) 743, 748 (C. C. A. 2) where Judge Learned Hand criticizes the promiscuous use of the term 'aggregation,' and says that in every case 'invention must depend upon whether more was required to fill the need than the routine ingenuity of the ordinary craftsman.' We think that this statement perhaps requires too little, but certain it is that something more is required than even a highly skillful selection of well-known means from the prior art to progressively perform their several functions. * * * Doubtless the conveyor design of Mahon, certainly as embodied in the commercial practices of the complainant, has met with favorable reception and has gone into broad use. Doubtless, also, it is a more serviceable conveyor than had theretofore been placed upon the market; but we fail to find in its underlying concept that spark of inventive genius which alone can distinguish it from an exercise of mechanical ability reasonably to be expected from the pneumatic engineer, and which alone would justify a patent."

Just here is where it seems that the courts must determine the question of invention in each case as presented. Does the underlying concept of Swan contain the spark of inventive genius?

If it does contain such spark of inventive genius then in connection with the presumption of patentability and failure to find anticipation in the prior art, leaves no alternative but to find the patent valid. The question is one of fact to be determined by the evidence, which persuades me that Swan displayed inventive genius. Perhaps the result is the determining factor in the process of arrival at such conclusion. Swan did show a manifold which gave better gas distribution, which was a

matter of great importance in the building of automobiles.

Swan saw what others did not, that the gasoline continued as a liquid in the air stream up the manifold, that whether the gasoline globules adhered to the inner surfaces of the manifold or rolled along the bottom, these globules must be broken up to secure even distribution, and his contribution was a manifold with rectilinear lines and right angle turns. This was a novel method and new in the art with Swan; in short, this was his invention.

In *Pyrene Mfg. Co. v. Boyce*, 292 Fed. 480 (1923) at p. 481 in an opinion of the 3rd Circuit, Judge Woolley said:

> "On the major issue of validity we shall first inquire whether the conception for which the patent was granted involves invention. Because of the lack of a definite rule, questions of this kind are often perplexing. It is a trite saying that invention defies definition. Yet, through long use, the word has acquired certain characteristics which at least give direction to its meaning. Invention is a concept; a thing evolved from the mind. It is not a revelation of something which exists and was unknown, but is the creation of something which did not exist before, possessing the elements of novelty and utility in kind and measure different and greater than what the art might expect from its skilled workers."

Swan's was a concept which conforms to this definition of invention.

THE ACHIEVEMENT OF THE SWAN MANIFOLD.

The defense of the Nash Company against the Swan patent is bottomed upon one premise; that Swan accomplished nothing in the art of manifolding, in fact that the Swan invention is not an advance, that it is not an achievement.

Yet from the writings of Tice in 1911 down until after the Swan patents appeared, the existence of the manifold problem has been of great concern to automotive engineers. It is even admitted that it would be a great achievement to produce an increase in power or a saving in fuel of as much as 2 or 3 per cent.

Before the advent of Swan the island type of manifold as used by Nash had been improved upon over a period of years by Engineer Wahlberg of the Nash Com-

pany and brought to its highest efficiency (Trans. p. 405). In 1923 the Swan engineers made comparative tests at the Nash plant with the Nash manifold and a Swan manifold, on a Nash engine, which showed favorably for the Swan manifold, following which the Nash engineer said that "Swan has made a real contribution to the industry" (Trans. p. 48), and following the suggestion of Mr. Nash, plaintiff did national advertising in 1925 to familiarize the public with its Swan manifold (Trans. 50).

In the letter of Engineer Taub of the General Motors Corporation (plaintiff's Ex. 26), March 22, 1922, he said after tests had been made by General Motors that:

> "As far as we have tested the Swan type of manifold, we are positive that this construction has many advantages over the accepted practice of today. The distribution has proven as perfect as can be made by manifolding, and the vaporization is practically complete.
>
> In every test that we have made using the principles shown in the Swan manifold, this has been borne out."

The commendation of this letter was given before General Motors had taken a license.

Others from Buick Motor Company who had commendation for the Swan manifold were Mr. Sage, Pence, Experimental Engineer, and Bassett, then President and General Manager of Buick, and DeWaters and Bower, Chief and Assistant Engineers of Buick, and Hartz, Engineer of Buick Testing Laboratory. In addition, there was Mr. Reuter, President of Olds Motor Works and Mr. Baker, Chief Engineer of Willys-Overland, and references to their statements are found in briefs of counsel.

H. L. Horning, a manufacturer of gasoline engines and an expert motor engineer, states that:

> "The art of building six-cylinder engines might be said to revolve about better valve materials until some better form of manifold could be designed," (Trans. 23e) "and after spending a hundred thousand dollars in trying to produce a good manifold, and research, and so forth, and consideration of the results we got, it seems to me that the simplicity of the Swan manifold is a very important thing * * * because of the saving in the cost of construction of

the usual manifold," (Trans. 23f) "and finally this Swan manifold is better than anything we have seen before." (Trans. 23i.)

Thus many automobile engineers accepted the Swan manifold and have said that it was an improvement upon the old island type of manifold. Buick took its license, proceeded to manufacture, and without cancelling sought to manufacture a manifold which it claimed was not within the bounds of the patent. Such claims were denied in the first *General Motors* case and are now pending in its second case.

After General Motors took this stand other members of the National Automobile Chamber of Commerce proceeded to manufacture, after experimenting with the Swan manifold, and suits are pending against Willys-Overland and Reo. Several engine manufacturers took licenses and there was an acceptance of the Swan manifold as an improvement.

Engineers and engine manufacturers have accepted the Swan method as an improvement over the old forms of manifolding and wherever contest was made, it was on the ground that they did not use the Swan method. In this case for the first time has the proof been offered that the so-called Swan method of manifolding is nonexistent, and the basis for this, of course, is the elaborate tests and testimony of Mr. Tice. Before this case there has been no proof offered either in publications or by tests showing with such accuracy and clearness the actual operation of the forces in a manifold.

Even if there were no other evidence before the court than the tests and testimony of Mr. Tice, the value and importance of Swan's invention and its title to be rated as an important invention would seem to be clear, for in his 1911 articles (plaintiff's Ex. 37) all of the statements which he now affirms (Trans. 1059) set forth the want, the need, the problem, its difficulties, and the failure of its solution notwithstanding the many efforts to improve manifolds as shown in his writings. The later work of Tice at the Stewart-Warner Company in efforts to find the solution of the manifold problem, resulted in patents which have been launched into the trade. While he has testified to many things and clearly shown and analyzed the operation of the forces and the actions of mixture in the manifold, it must be still said that Swan did add to the solution of the manifolding problem, that while he may not have secured scientifically "equal dis-

tribution," he did secure "good commercial distribution" in the operation of his manifold. So that under the heading of utility the Swan invention has met the test of invention prescribed by the patent courts.

TESTS AND EXPERT TESTIMONY.

The tests upon which plaintiff relies include the usual road tests, that is, acceleration, hill-climbing and economy. Spark plug tests and gas analysis tests were also offered in evidence. Expert testimony for plaintiff was given by Frank L. Sessions who testified in the *General Motors* cases, Kirkham, engineer for plaintiff, and President Pelton of the plaintiff company. Generally speaking, in offering its testimony, plaintiff covered the same ground as in the *General Motors* cases and much of the testimony from those cases was stipulated into this record.

Defendant also relies upon the record in the *General Motors* cases for most of its evidence as to prior art, the only new evidence being as to the 20th Century manifold. For its defense to the patents, the new evidence upon which defendant principally relies, is the expert testimony and tests made by or under the supervision of P. S. Tice. This is the same P. S. Tice whose article on the prior art appeared in "Motor" of May, 1911, and Judge Westenhaver, in *Swan Carburetor Co. v. General Motors Corp., supra,* said "his description of the existing art in manifolds and of the problems involved may be accepted as correct."

The tests conducted by Tice in the Master's presence at the factory of the White Motor Company showed the performance of liquid gasoline at the elbow of manifolds. Also later at the same factory, he operated another test on a Murray & Tregurtha engine with a glass window on its manifold. The Cox indicator tests at Detroit were made under the supervision of Tice and results became a part of his testimony. The tests made with the Cox indicator used a delicate, scientific apparatus, the record sheets of the tests being in evidence. To better show the operation of the forces, test apparatus was operated by Mr. Tice with Neon lights and stroboscope, and the record contains two reels of moving picture film showing the manifold in operation driven by a dynamometer.

In addition to Mr. Tice as a practical carburetion engineer, defendant relies upon Professor Cooley of the University of Michigan, Dean Emeritus of College of

Engineering, a scientist who testified as to the behavior of flowing liquids.

With these tests made by defendant, an explanation is offered of the problem involved in the operation of forces in a manifold. The facts were developed and shown in the actual operation of test apparatus and probably were publicly viewed for the first time. There was no such proof offered in the *General Motors* cases, as the record shows. The operation of the forces as pictured by defendant's tests was unknown to plaintiff's expert, Sessions, and could not be described by him (Trans. 195) for he says "the exact action of mixture is measurable only by results, so far as I know * * *. We know what it performs, but we don't know the manner by which it performs it."

The operation of the forces in the manifold was also unknown to Swan, as appears from the first statement of his original application for patent, where he states his inability to describe such forces.

With the Tice tests offered by defendant, showing operation of forces in a manifold, has this new evidence destroyed the Swan patents? Judge Westenhaver said that the Tice 1911 description of the existing art and manifolds might be accepted as correct, and that Swan sought to solve the problem Tice had stated and discussed; and he found that Swan solved the problems involved "by introducing a new and original principle of operation. The gist of his invention consists in bringing the gaseous mixture from the carburetor to the header in perpendicular or straight lines, then abruptly changing its course at right angles in the header, and then again changing its course at right angles from the header into the branches."

Judge Westenhaver goes on to say that all other features of Swan are subsidiary, that while he might have stressed a dome or flat wall, the recesses in the outer bend, flat or level floors, or even square cross-section, such were not made by Swan as the substance of his invention.

THE NEW PROOF AS TO METHOD AND OPERATION OF FORCES IN A MANIFOLD OFFERED IN THE TICE TESTS AND THE SWAN CLAIMS TO INVENTION.

Distribution of the liquid gasoline to the various cylinders is the function of any manifold. "Equal distribution" of such gasoline is the claim of the Swan patents.

Defendant claims that the description of the entire mode of operation of the Swan manifold is incorrect as stated in the patents and that the record fails to show that either Swan or plaintiff's experts described or understood the actual operation of the mixture in a manifold. Plaintiff asserts that patents in suit describe the operation and that its experts have testified sufficiently as to this (Trans. 104-109, 1334 and 1530).

Relying upon the Tice tests, particularly those made with a Cox indicator, known in this record as the Detroit tests and the Fulwiler tests, defendant urges that a Swan manifold on a Nash engine (plaintiff's Ex. 375) distributes gas unevenly to different cylinders, and so fails to effect the "equal distribution" essential to the "Swan method" of the patents.

Plaintiff's answer is in substance, that no matter what some delicate, scientific laboratory apparatus may show as to any variation of gasoline as received and recorded upon the aspiration of any individual cylinder, the effect is that the Swan manifold gives "good commercial distribution," which in itself is invention; was unknown in the prior art, and is an improvement on the prior art; and which defendant has appropriated without license and is now an infringer.

With the help of most delicate electrical apparatus in the laboratory, Mr. Tice has shown every step, in fact every instant, in the travel of gasoline from carburetor nozzle, past the butterfly throttle up the riser, around the bends, into the header, around another bend into the branches, and finally into the cylinder for use in the separate aspiration of each cylinder. These globules of gasoline move at "hurricane speed," varying with the engine speed which operates at 800, 1200 or 1800 revolutions per minute, at the rate of 120 miles per hour at 1200 R.P.M. (Trans. 1169). Most complete is the Tice analysis of these operations, by charts, diagrams and photographs of operations, which were viewed in the tests at the White plant, with and without Neon lights. Finally two moving pictures of the tests are articulated in one film so that the audience may have before it at one time, in a single view, a birdseye view into the top of the manifold and a view into the side, showing side by side the two views of the interior of the manifold, as the mixture containing particles of gasoline is sucked in for each separate aspiration of the six cylinders.

Without attempting to describe the different phenomena pointed out by Mr. Tice in a single cycle of the

six aspirations of the several cylinders, which include gasoline on riser walls, its behavior at the T, the eddies at the corners or bends, the hot and cold blow-backs, the impingement or failure to impinge of liquid gas at the ends, the action of the valves and the quick reversals of the flow of mixture as different cylinders operate, the claims of operation as shown by the Tice proof must be considered as against the claims for the Swan method of the patents.

Counsel for defendant claim for the Tice proof that it establishes:

(a) That while Swan claims to start with a homogeneous mixture of gas particles and air and that such character of the mixture is maintained until delivered to the different cylinders, defendant denies that the mixture of air and gas is homogeneous to start with and never becomes homogeneous.

(b) That the mixture does not move up the riser in rectilinear lines but has an inherent turbulent motion with deflections due to carburetor intake, nozzles and throttle, which prevent movement in rectilinear lines; that because of the swirling motion most of the liquid is deposited on the walls of the riser where it accumulates unevenly and is blown up the riser in uneven streams.

(c) That the square shape of the Swan riser does not prevent the swirling of the mixture, which Tice shows does swirl and deposits liquid unevenly on the riser walls.

(d) That the mixture, on reaching the top of the riser, does not impinge on the flat surface of the header above the riser and that the Swan method ignores what Tice shows, that the mixture stream bends around the corner at the top of the riser in a curved path and does not impinge upon the ceiling; yet there is proof that the liquid globules of gasoline in the mixture do strike the top of the header at or near the riser, and this is a scientific fact based upon the action of inertia, for the liquid gasoline being heavier than the air part of the mixture as the turn is made, is thrown against the header due to the force of inertia. The result is the impingement, so-called, of the plaintiff's patent and its effects were to be seen in all tests viewed by the court.

(e) That the mixture, when it reached the T or the so-called distributing zone, makes a right angle turn, is challenged, because of the speed of the mixture and the

pulling force, the mixture is shown by the pictures to bend as it changes direction at the right angle turns of the manifold, and the Tice tests show the path of the mixture in curves as large or as "sweeping" as the diameter of the manifold will permit.

(f) That there is no spattering or rebounding of the particles of gasoline in the mixture at the turns, although such descriptive words fairly well describe what is seen in the tests made, which were observed in this case and the *General Motors* case, and were accepted by Judge Westenhaver and the defendant in that case; only in the new tests made by Tice with the aid of Neon lights and stroboscope other phenomena appear and spattering and rebounding are not the only visible results of the effects of the forces in operation.

(g) That the liquid accumulates in eddies and forms puddles or reservoirs in the header and center branch at points just beyond the corners at the top of the riser; which eddies or accumulations were first shown by Tice tests and are ascribed by plaintiff's expert to the turbulence of the mixture and such eddies or accumulations flatten out and practically disappear when there is a change of direction in the flow of the mixture as it is pulled from one end of the engine to the other as the different cylinders aspirate, which change of direction is also accompanied by the hot and cold blow-backs, and the Tice tests show that there is some variation in the richness of the mixture as received by the end cylinders compared to the center cylinders.

(h) That after the mixture leaves the T it does not flow in rectilinear lines to the branches, is untrue for practically all of the liquid particles of the mixture are on the walls and such as are in the air stream at the T immediately come into contact with the walls to which they adhere.

(i) That the liquid particles are not projected beyond the sharp inside corners at the ends of the header and are not remixed in the gas stream, for Tice says that the liquid is substantially all on the walls.

(j) That the absence of liquid accumulations of the Swan method is untrue, for Tice points out eight places where accumulations or reservoirs of liquid assemble due to eddies.

(k) That such equality of distribution as has been obtained by Swan has been due to the application of

heat on the exhaust jacket which has produced evaporation in the riser, but for which heat application there would be larger accumulations of liquid in the header and branches; and that whatever commercial success the Swan manifold has had, has been due to this application of heat to the riser, which vaporizes most of the liquid before it reaches the T, so that this vapor mixes with the air and is evenly distributed to the cylinders.

(l) That increased economy is not obtained by the Swan manifold since its lack of equal distribution requires in practice the setting of the carburetor rich enough to bring up to the necessary richness cylinders that run lean, and this practice produces an unnecessary richness in other cylinders and causes fuel waste.

Defendant urges that there is no proof of equality of distribution by the Swan manifold; that the only way to test equal distribution of liquid by a manifold to each individual cylinder is to test the mixture in each cylinder separately from the mixture of other cylinders, and to establish this claim the new proof of the Tice tests is offered.

Defendant urges that commercial success, acquiescence by the taking of licenses, or statements of engineers skilled in the art do not establish the Swan method or that the mixture is equally distributed as against proof tendered in the Tice tests; further, that road tests evidence only the over-all performance of the engine and give no information as to the method or quality of the distribution.

As before stated, the court must weigh the evidence and consider the effect of the new proof offered by Mr. Tice in this case.

The motion pictures show particles of the mixture striking the roof of the header opposite the riser (plaintiff's Exs. 117-123 incl.). Even if this be only a part of the mixture, yet it is in the method of the patent and is a phenomena described by Swan and one which has been shown in all tests heretofore made.

The stroboscopic demonstrations on the glass manifold at the White Plant showed the liquid particles hitting the roof of the header opposite the riser, and liquid particles were also seen hitting the roof of the header opposite the riser at the road demonstration, with a glass manifold on plaintiff's test car.

The elbow demonstrations with and without the stroboscopic lights demonstrated movement at the turns,

notwithstanding the controversy between experts as to the presence of turbulence as contrasted with eddies and accumulations. Particularly as to the Murray & Tregurtha manifold, with a glass header, it was apparent in the tests that the mixture was unevenly distributed for greater quantities of liquid flowed to the front of the header than to the rear, and confirmed the testimony of the failure of the Murray & Tregurtha manifold to give equal distribution. Colchester (Trans. 1409), Kirkham (Trans. 1427), and Sessions (Trans. 1543).

Finally, while Tice has shown much new information as to the phenomena of the movement of the mixture in the manifold which was unknown before the tests offered in this case, it cannot be said that the concept of Swan did not add something new to the art of manifolding, so that his patents may now be denied because of the new proof offered by the Tice testimony in this case. While his method may not effect "scientifically equal distribution," he did give "commercially equal distribution" and made an advancement in the art of manifolding.

DEFENSES TO THE PATENTS IN SUIT.

Defenses to the patents in suit urged by counsel are indefiniteness, functional claims, belated amendments to enlarge scope of application, contentions as to the file wrapper, and anticipation of method claims of first Swan patent, which will be considered in order.

The Defense of Indefiniteness is urged and seems to be on the proposition that Swan patents do not describe all the forces which tend to distribute the fuel mixture. Yet the law seems to be, if the applicant states fully enough the scientific principles and the forces involved in the operation of his method, that he is considered to have solved a problem and be entitled to a patent.

The law only requires as a condition for protection that the world be given something new and that the world be taught how to use it. *Diamond Rubber v. Consolidated,* 220 U. S. 428, 435 (1911). The rule is stated in *Walker on Patents,* 6th Ed., Sec. 218, pg. 292:

> "It is enough to describe one particular mode and one particular apparatus by means of which the process may be performed with at least some beneficial result."

While it might be said that Swan did not completely and scientifically define his process or method, he defined them sufficiently to meet the requirements of the patent law. He did describe the apparatus in which the method could be performed. The patent drawings show to one skilled in the art not only one apparatus, but a preferred apparatus and modified forms for carrying out his process. Mr. Sessions, for the plaintiff, summarized this (Trans. 1522):

> "In fact, my opinion that the Swan patents adequately and accurately describe the structure and operation of the Swan inventions, has been made stronger by my observations of Mr. Tice's demonstrations, both of the glass manifold, the transparent manifold on the engine, the moving pictures and the operation of the engine at Detroit."

The Defense of Functional Claims is urged on the basis that the claims do not say what the forces are or how they are to be identified, which distribute the mixture uniformly in all directions. The rule seems to be that the method claims are valid, even though functions may be recited in them.

The function of the Swan machine and the Swan method is equal distribution of the mixture. This function is not recited in any of the claims in suit, and if it were such claim would not be functional unless patentability depended upon recitations of the function.

For instance, in claim 9 the steps are the moving of the mixture to the T from which it is distributed in three directions and subjecting the movement to forces which distribute the charges alternately in each direction in a plane transverse to the original movement. These are steps in the method and not in the function, which is the distribution of charges to the cylinders in equal proportions. The method or process of this claim is typical and is the orderly succession of movement of the fuel mixture to the T, changing its direction of movement at right angles and alternately sucking the mixture from the T, first in one of three directions and then in another.

Swan discovered that the effect of centrifugal force "acting to throw the liquid particles out of the intended aggregate line of travel, and thereby separating the mixture constituents," gave unequal distribution in the prior art manifolds. His method proposes, pg. 2, line 23, first

patent, "the liquid particles in the air fuel mixture instead of being thrown in a direction not intended, as at some curve, are influenced to move in a proper direction and thereby the mixture will be delivered to all the cylinder ports substantially alike." Thus by the effects of centrifugal force and inertia, he claims for his method the successive steps of moving the mixture from one point to another, i.e., through the T with its turbulence or its adjacent eddies, and thus from one stage of remixing to another. Swan uses those forces for his new purpose, but does not seek to claim the use of old and well-known force. Thus with such known forces as the suction from the engine and the inertia of the fuel particles, Swan discovers a method by which substantially equal distribution of the constituents of the fuel mixture was effected between the several cylinders of the engine.

So that in this case, as in *New Fermentation Co. v. Maus,* 122 U. S. 413 (1887), where a similar argument was made, this is a mode of treatment to produce a given result and the patent requires certain things be done with certain substances and in a certain order, and is therefore a process or art.

The Defense of Belated Amendment Which Seeks to Enlarge the Scope of the Application: Counsel urge that Swan described and claimed the square section manifold and disclaimed the round section in his first application. Yet he illustrated a manifold round in cross-section and described and claimed such a manifold. Disclaimers are in the nature of estoppels and only apply where the intention to abandon is clear and unequivocal. Nothing less will prevent the resort to the doctrine of equivalents. *Winans v. Denmead,* 15 How. 330 (1853).

In considering the disclosure of the original Swan application, it is to be remembered that patent specifications and other disclosures are directed to those skilled in the art. Without further considering the measurements, figures and descriptions of the patent, it suffices to say that it does not matter whether the Swan application shows a round manifold or not, so far as this case is concerned. Professor Cooley has stated that the making of the manifold round instead of square would not make any difference (Trans. 1180). Even if the patent only showed a square manifold, infringement would exist under the doctrine of equivalents. *Societe v. U. S.,* 224 U. S. 309, 328 (1912).

That the Swan method was disclosed in the original application was held by Judge Westenhaver and by the Commissioner in the *General Motors* cases, and recently, in considering the Commissioner's report in the second *General Motors* case, Judge Hahn said on this subject:

> "It is enough that the language at pages 243 (14-25) and 244 (11-16) suggest a principle or method of operation, (or a sufficient basis for amendment) not dependent upon specific form of device, and no language of the specification directly or by implication excludes the possibility that the essence of Swan's invention may be a principle or method of operation not dependent for its successful operation upon any particular embodiment as to form."

The authority urged by counsel, *Railway Co. v. Sayles*, 97 U. S. 554 (1878), holds that new matter could not be added which was at variance with the original; in this case the holdings have been that the method was disclosed in one original application.

That a patentee may amend his specification from time to time, making no additions in substance or material variations from the original disclosure, is well established; *Michigan Carton v. Sutherland Paper Co.*, 29 Fed. (2d) 179 (C. A. 6, 1928), where Judge Knappen said, at pg. 184:

> "The rule is that insertions by way of amendment in the description or drawing, or both, of a patent application do not invalidate the patent, if they are only in amplification and explanation of what was already reasonably indicated to be within the invention; and this rule applies with special force where the insertion was required by the Patent Office. *General Electric Co. v. Cooper, etc., Co.*, (C. C. A. 6) 249 F. 61, 64, certiorari denied 246 U. S. 668, 38 S. Ct. 336, 62 L. Ed. 930. And if an inventor comes to better understanding of the principles of his invention while his application for patent is pending, an amendment of his claim to conform thereto does not introduce any original matter nor enlarge his invention, and is within his legal rights. *Cleveland, etc., Co. v. Detroit, etc., Co.*, (C. C. A. 6) 131 F. 853, 857, *et seq.*; *Proudfit Co. v. Kalamazoo Co.*, (C. C. A. 6) 230 F. 120, 141."

It hardly comes with good grace for a member of the National Automobile Chamber of Commerce to

charge that the plaintiff has interfered with their manifolding business. The record shows that when manufacturers were struggling with the old island and other types of manifolds, that Swan showed them the advantages of the Swan manifold which would handle a wet mixture better than had ever been done before. At expense to plaintiff, defendant was taught the merits of the Swan invention and manifolds were "tailored" to operate on defendant's engines. And now, plaintiff is entitled to protection for its patent, from infringers who have copied the Swan manifold.

File Wrapper Contentions: Defendant urges that the essence of the invention as Swan originally conceived it lay in a square or rectangular cross-section manifold with flat bottom, flat ceiling and flat surfaces against which the mixture could impinge, with the avoidance of liquid accumulations and the absence of curves, both in cross-section and in the direction of the flow of the mixture. Defendant asserted similar limitations for plaintiff in the *General Motors* cases. Yet on such broad disclosure in the first instance Swan should not now be estopped to assert the broad construction of the present patented claims. Examination of the Swan file wrapper could not lead one to believe that Swan intended to limit himself as defendant urges. Of the meaning and effect of patent claims, *Walker on Patents,* 6th Ed., Sec. 219, says:

> "To use the words of the Supreme Court, 'the claims measure the invention,' and 'apprise the public of what is still left open to them'."

and in Section 234:

> "Likewise a patentee of a manufacturer is not restricted to a construction which he describes in the specification merely as 'preferable' unless specifically limited by the claims."

If, as defendant urges, the essence of this invention was the square manifold or flat bottom, the avoidance of curves and the avoidance of liquid accumulations, such issue as to supposed limitations was disposed of in each of the *General Motors* cases and has heretofore been commented upon.

Method Claims of the First Swan Patent are not Anticipated: Defendant urges that method claims 4, 5 and 8 are anticipated in the Murray & Tregurtha mani-

fold if these claims be construed to cover defendant's "Special Six" manifold which is asserted to be identical in shape with Murray & Tregurtha, also method claims 9 and 10 are urged as literally anticipated by Murray & Tregurtha.

The burden of proof that the prior art devices of Murray & Tregurtha operate like Swan and realize the Swan method of operation is ever upon the defendant. The rule is that the burden rests upon the defendant to prove that the prior art device operates like the patented device or like defendant's device. *Coffin v. Ogden,* 18 Wall. 120 (1870).

Defendant cannot escape this issue for, as stated by Judge Westenhaver in *Fulton v. Bishop & Babcock,* 284 Fed. 774 (1922), and again in the 6th Circuit, 17 Fed. (2) 999 (1925) in the same case, *Bishop & Babcock v. Fulton,* 37 Fed. (2) 293 (1930), the second syllabus is: "Patentee of process is entitled to have patent construed broadly enough to cover the meritorious thought of his process." The opinion is by Judge Moorman, and for this rule he relies upon *Tilghman v. Proctor,* 102 U. S. 707, 728 (1880), and *Eibel Process v. M. & O. Paper Co.,* 261 U. S. 45, 63 (1923).

Defendant relies upon the rule of *Knapp v. Morss,* 150 U. S. 221, 228 (1893), that what would infringe if later would anticipate if earlier. Judge Westenhaver thought that the Matheson manifold was the nearest to the Swan, and the proof is here lacking that the Murray & Tregurtha manifold is identical with Swan in respect to performance, mode of operation and achievement. Defendant also urges that the 20th Century manifold and the Fiat also anticipated the method claims, and what has been said here as to Murray & Tregurtha applies equally as to these.

PRIOR ART.

All of the prior art relied upon in this case was relied upon and considered in one or both of the *General Motors* cases. The conclusion there reached was that

The Swan Patent is a Pioneer in Manifolding.

The manifold art was illustrated and discussed in the articles by Mr. Tice in Motor (plaintiff's Ex. 37) for April and May, 1911, and the Swan principle of manifolding seems to have met the difficulties experienced by inventors and manufacturers of gasoline engines. *Gordon*

Form Lathe Co. v. Walcott Machine Co., 32 Fed. (2) 55 (C. A. 6, 1929), *Byers v. Keystone Driller*, 45 Fed. (2) 283 (C. A. 6, 1930).

The opinion of Judge Westenhaver, with the affirmance of the Court of Appeals, states the rule that patents are to be construed according to the order of importance and the degree of the advance in the invention patented. Any doubt as to the scope or the effect of the patent should be resolved in favor of the patentee, with increasing liberality where the patent is basic and marks a great advance in the art, as Mr. Chief Justice Taft said, in *Eibel Process v. M. & O. Paper Co.*, 261 U. S. 45 (1923, pg. 63):

> "In administering the patent law, the Court first looks into the art to find what the real merit of the alleged discovery or invention is and whether or not it has advanced the art substantially. If it has done so, then the Court is liberal in its construction of the patent to secure to the inventor the reward he deserves * * * the application of the rule *'ut res magis valeat quam pereat'* has been sustained in so many cases in this Court."

The prior art relied upon consists of

(1) *Patents in Exhibit 398*, 29 in number, which were cited by the Patent Office Examiner in one or other of the Swan applications and were relied upon and exhibited to the court in the first *General Motors* case.

(2) *Other Patents and Publications*, in the second *General Motors* case, which included patents to Sundh (defendant's Ex. 394) and Koken & Pichl (defendant's Ex. 395).

(3) *Manifolds Shown in Exhibit 380*, 6 in number, not shown in patents, all of which were in the second *General Motors* case and some in the first case. Considering these prior art items, all of the patents in the first group relied upon are paper patents which have had no commercial use (Trans. 1582). While a paper patent may anticipate, yet if it never found commercial favor, it has little force and credit on the question of non-invention. *Republic v. Youngstown*, 272 Fed. 386 (C. C. A. 6, 1921), *Wellman v. Cramp*, 3 Fed. (2) 531 (C. A. 6, 1925), and *Gordon v. Walcott, supra.*

From the large number of manifolds used, many are illustrated in the Tice articles, some in Exhibit 380, and

Matheson is shown in both the Tice articles and in Exhibit 380. The record does not show that any of the 6-cylinder manifolds of the Tice articles or of Exhibit 380 were in production when Swan entered the field, except perhaps the Fay & Bowen and the Franklin, which manufacturers later adopted the Swan manifold. Of the users of 6-cylinder manifolds illustrated by Tice, only three, Franklin, Pierce Arrow and Oldsmobile were still in business at the time of the trial (Trans. 1059) and these three became licensees adopting the Swan manifold (Trans. 31).

The record fails to show that anyone, except defendants contesting the Swan patent, has ever claimed that the prior art manifolds employed the Swan mode of operation. In this case Mr. Tice testified that none of the manifolds in defendant's Exhibit 380 employed the Swan mode of operation and that none of them realized equal distribution (Trans. 1084).

Since the manifolds of defendant's Exhibit 380 are conceded by the experts of both parties to be those nearest to Swan, all evidence of other manifolds in patents or publications loses its probative effect if those of Exhibit 380 fail as to prior art.

The rule is that the burden is on the defendant to show that the prior art device operated like the patented device and performed its functions. Defendant must show that the prior devices it produced are "capable of producing the results sought to be accomplished," as required in *Coffin v. Ogden*, 18 Wall. 120 (1870). Defendant cannot escape this issue for, as stated by Judge Westenhaver in *Fulton v. Bishop & Babcock*, 284 Fed. 774 (1922), and again in the 6th Circuit Court of Appeals, 17 Fed. (2) 999 (1925), in a *Per Curiam* opinion on rehearing, pg. 1007 (1927), anticipation is not effected by an arrangement which was not adopted and used to perform the function which was performed in the patented invention. So, as the Supreme Court said in *Coffin v. Ogden, supra*, "the burden of proof is upon defendant to prove these things, and every reasonable doubt should be resolved against him." Defendant must prove that prior devices were capable of and adopted or used to perform the Swan functions or embody the Swan principle of operation. The record is clear, that if any of the manifolds of the prior art ever did operate like Swan or realize equal distribution, such was accidental and unrecognized.

That the Swan method might have been performed by one or another of the prior art manifolds if operated under certain conditions is no answer; for the rule is well established that a method or process cannot be anticipated by a device in which it might have been performed. *Carnegie Steel Co. v. Cambria Steel Co.*, 185 U. S. 403 (1902); *Nestle-LeMur v. Eugene*, 55 Fed. (2) 854 (C. A. 6, 1932).

Murray & Tregurtha Manifold. Experts for both parties in this case agree that this manifold comes nearest to looking like Swan and when placed on a 3-cylinder engine as it was used, ought to come nearer than others to doing what the Swan manifold does on a 6-cylinder engine. The experts also agree that fuel distribution to a 6-cylinder engine is more difficult than distribution to a 3-cylinder engine (Trans. 1179), so if Murray & Tregurtha solved the problem that Swan solved, with the 3-cylinder engine, the Murray & Tregurtha manifold would not necessarily anticipate one who solved the more difficult problem of the 6-cylinder engine. Tests of the Murray & Tregurtha glass manifold (defendant's Ex. 382) failed to show equal distribution on a 3-cylinder engine, so there is no need for the court to speculate as to what could be done on a 6-cylinder engine. It would seem to be sufficient to say that the Murray & Tregurtha manifold cannot be held to anticipate Swan because there was no problem of distributing the mixture at the end of each of the branches.

Fiat manifold. Of the 6-cylinder manifolds, Mr. Tice as defendant's expert, picked the Fiat manifold as best of all. This is based on the testimony as to a Fiat-manifold-Greuter-carburetor device which is claimed to anticipate Swan. The Fiat manifold (defendant's Ex. 272) with the testimony of Rowan (Trans. 1480-81, 1490) shows efforts to correct fuel distribution, failure, and that the Italian experts were called to remedy trouble with the manifold, which efforts were unsuccessful. The most that can be said for the Fiat manifold is that, as modified by the witness, it can only rate as one of several prior efforts and failures to do what Swan did.

Matheson Manifold. In the first *General Motors* case Judge Westenhaver picked Matheson and Peerless as the best of the manifolds in the prior art, following the testimony of plaintiff's expert, Mr. Sessions, to the same effect. Also in the second *General Motors* case defendant's expert, Schwartz, considered the Matheson manifold to be the best.

The Matheson manifold is also one of the 76 manifolds illustrated in the Tice article in which he says that

they fail to effect equal distribution, and commented upon the inability of the devices of the then existing manifold art to equally distribute the fuel mixture. The faults of the Matheson manifold were testified to by several witnesses. Dean, who had operated a Matheson car, said the center pair of cylinders, 3 and 4, fouled and were apparently getting more mixture than others (Trans. 1395-6). Parker, who had operated a Matheson car with Matheson manifolds in 1911, said the motor was never smooth or flexible and missed when running slow (Trans. 1400). Greuter, who had been a Matheson engineer and knew the Matheson manifold, said that on tests he had made the cylinders connected to the center branch would invariably get more gas than the end ones (Trans. 1402). The Matheson manifold, like the others, must rate as a prior effort and failure instead of a device anticipating the Swan invention.

Pierce Arrow Manifolds. Two types of Pierce Arrow are relied upon (defendant's Ex. 252), and the modified Pierce Arrow shown in Exhibit 249 (also shown in Ex. 380).

These manifolds were used upon one of the finest and highest priced cars, its engineering and equipment being considered of the highest order. The manifold shown in defendant's Ex. 251 was unsatisfactory, and witnesses were called to show how the standard Pierce Arrow manifold was improved, yet the Pierce Arrow manifold as modified is not considered as close to Swan as Matheson or Peerless by any of the experts. These also must be regarded as a prior effort and failure before the advent of Swan.

Fay & Bowen Manifold. This manifold (defendant's Ex. 229) was also presented in the trial in the *General Motors* case, and the proof it offered was considered by Judge Westenhaver only as cumulative. This manifold was also used on marine or other 6-cylinder engines, and its performance was inconsistent with any claim of the Swan principle or result, for Ware said "the Swan manifolds were very much better" (Trans. 1438, 1442). This also represents a prior effort and failure.

New York Yacht & Engine Manifold (20 Century Manifold). This is shown in defendant's Exhibits 380 and 268. Testimony is meager and fails to show that it realized the Swan principle or the Swan results. It can only be classed as a prior effort which does not anticipate.

INFRINGEMENT.

The Nash Company, like many other automobile manufacturers, had been using the island type of manifold for several years (Trans. 404). After the plaintiff conducted experiments at the Nash plant, showing the improvement to be effected by the Swan manifold over the island manifold, Nash adopted the manifold which is claimed to be the Swan manifold, there being this difference, the manifold as adopted was of round cross-section instead of square, which Professor Cooley says makes no difference in operation. This manifold became standard equipment with Nash and defendant has never gone back to the island manifold since the change was made.

That the manifolds adopted by Nash (plaintiff's Exs. 41-A, 42-A, 43-A, 45-A and 46-A) and disclosed in drawings (plaintiff's Exs. 40 to 46 incl.) operate like and get the same results as Buick manifolds (plaintiff's Exs. 9, 10 and 11), which Buick manifolds were held to infringe in the *General Motors* suits, is the testimony of Engineer Wahlberg, Vice-President in charge of Engineering of the Nash Motors Company (Trans. 418, 419, 427, 428). The qualifications of Engineer Wahlberg are not in question. A strong case is one which can be proved by cross examination of opposing witnesses, said Mr. Chief Justice Taft, *Eibel Process Co. v. M. & O. Paper Co.*, 261 U. S. 45.

Such result is further confirmed by the testimony of plaintiff's experts, and the outdoor tests which included economy, hill-climbing and acceleration tests. These are the standard tests accepted by the automobile and internal combustion engine industry for testing manifolds, carburetors and equipment to determine operation and relative performance. The challenge of the defendant is that such standard tests should now be discarded in favor of the laboratory tests as conducted by Mr. Tice on manifolds driven by a dynamometer and tests with a Cox indicator.

The broad claims in suit, Patent No. 1,536,044, claims 4, 5, 8, 10, 20, 22 and 23, are infringed for the same reasons that they were infringed by the manifolds in the two *General Motors* cases.

The method claims of the first patent cover what Judge Westenhaver characterized as "the new and original principle of operation" which Swan invented. Some of these claims cover a 3-step method and some of

them a 2-step method, and some are limited to a six-cylinder engine. Claim 10 is typical, is limited to a six-cylinder engine, employs a 3-step method, which are the characteristics of the defendant's manifolds charged to infringe. The claim may be analyzed into various steps, as follows:

(1) "A method of distributing a fuel mixture to a six-cylinder engine which includes moving the mixture to a zone through which it is distributed in three directions in a plane transverse to said movement,

(2) subjecting said movement to forces tending to distribute charges in alternating directions and in uniform character in all of said directions, and

(3) further subjecting the movement of the mixture towards adjacent pairs of cylinders to forces tending to qualify the charges for said pairs in substantially equal portion of wet mixture constituents."

The opinion evidence and the tests of plaintiff show that defendant's manifolds employ all of the steps recited in this claim, and defendant denies that the Swan manifold so operates.

Notwithstanding defendant urges that the claims are invalid because the method claimed is not performed by the Swan manifold, plaintiff must prevail on this issue which has been considered in the discussion of the law on the subject.

Improved Performance of Infringing Device, No Defense. It would not avail defendant if it had established that the Swan manifold with the round cross-section performs better than the Swan manifold with a square cross-section. This is only a matter of degree and the same claims were made by witnesses Sage and Bower in the *General Motors* cases as to the Buick manifolds there held to infringe.

The performance and operation of the Buick manifolds tested with the Swan was so clearly alike that they could not be fairly distinguished (Trans. 128-157 and 187-88), which is also supported by the admission of witness Sage as quoted by witness Pelton (Trans. 1229).

The rule is that where there is a mere improvement on the device, that infringement can never be

avoided by thus improving the patented device and making it work better. This rule is stated by Mr. Chief Justice Taft in *Temco v. Apco Co.*, 275 U. S. 319 (1928) at pg. 328, as follows:

> "It is well established that an improvement cannot appropriate the basic patent of another and that the improver without a license is an infringer and may be sued as such." *Cochrane v. Deaner, supra,* and other cases.

DEFENSE OF LACHES.

Defendant urges that plaintiff has been guilty of laches in the prosecution of this suit filed late in 1926 and brought to trial in September of 1932. Before considering the application of such principle to this patent cause, a review of the steps taken in the litigation over the patents in suit seems necessary.

The bill of complaint in this cause and the petition in the first *General Motors* case were both filed in November, 1926. The *General Motors* case was heard by Judge Westenhaver in April, 1927, and judgment entered on September 27, 1927; decision in the Court of Appeals was had in June, 1930, and rehearing denied November 5, 1930, after which Writ of Certiorari to the United States Supreme Court was denied January 12, 1931.

By stipulation of counsel this case was dropped from the trial calendar in May, 1927. The second patent in suit was issued in July and the plaintiff restored the case to the trial calendar, filing a supplemental bill of complaint in September, 1927.

Following Judge Westenhaver's decision in the *General Motors* case, on November 12, 1927, counsel moved to reopen the *General Motors* case, claiming newly discovered evidence in the Murray and Tregurtha matter, and on the 18th of November amended its answer in the case at bar by adding such new matter to its defenses here.

This case was on the calendar ready for trial; parties stipulated parts of the General Motors record as appears by plaintiff's Ex. 25; and any part of the General Motors record that either party desired was to be used in this case. After Judge Westenhaver's death in 1928, by consent of counsel the case was again dropped from the trial calendar during the appeal of the first *General Motors* case and the case was not reinstated until October of 1929.

On November 18, 1929, his Honor, Judge Jones, ordered this case be passed pending the decision of the Court of Appeals in the General Motors case, and the first *General Motors* case was concluded by the denial of Writ of Certiorari in January, 1931.

Meanwhile the second *General Motors* case had been filed and was set for hearing April 15, 1931, and awaiting the outcome of this second case, counsel stipulated an extension in the case at bar until May, 1931. Also in May defendant amended its answer to include the 20th Century manifold as used by it and by General Motors as an alleged prior use. Also, defendant offered two more amendments in May, 1931, regarding Fiat and other manifolds, to which amendments plaintiff made no objection but asked delay of trial until the newly asserted defenses could be investigated. Counsel thereupon agreed that the case be dropped from the trial calendar.

Trial of the second *General Motors* case began in the Fall of 1931 and the case was submitted to the Commissioner late in the Spring of 1932. After the testimony was concluded in that case, the case at bar was reinstated on the trial calendar and the order of reference to the Master bears date of May 26, 1932. After the reference the Master stated to counsel for both parties that he would not proceed with the trial of this case until the *General Motors* case then on hearing was concluded. The Commissioner's report was filed with the District Court on August 15th, and after several conferences with counsel about proceeding to trial, the first testimony in this case was taken on September 28, 1932.

Counsel for defendant rely on the leading case of *Johnston v. Standard Mining Co.,* 148 U. S. 360 (1893), where it was stated that the mere institution of a suit does not relieve from the charge of laches and that if plaintiff fails to diligently prosecute the action that the consequences are the same as though no action had been begun.

Counsel further rely upon *Kellogg Switchboard & Supply Co. v. Dean Electric,* 231 Fed. 197 (1915), where Judge Clarke cited *Johnston v. Standard Mining, supra,* and stated that plaintiff had shown such lack of diligence in the prosecution of its claim that it deserved no relief in a Court of Equity, and further stated that "laches is a defense which can be made without any pleading to support it." There seems to be no analogy between the

facts of that case and the case at bar for there the plaintiff did absolutely nothing for a period of ten years. In this case the plaintiff has been busy prosecuting matters concerning this patent and defendant has acquiesced in delays except the delays which have followed upon Court orders.

Defendant has not pleaded laches as a defense and has offered no support for such defense, whether pleaded or otherwise, and under the new equity rules it seems is not entitled to raise a defense not pleaded. *Walker on Patents*, 6th Ed. Sec. 632, pg. 728:

> "The defense of laches could formerly be made in a demurrer, or in a plea, or in an answer, or in an argument on the hearing without any pleading to support it. Of course now this defense can be made only by answer or motion to dismiss accordingly as the situation permits."

The rule also seems to be that a mere lapse of time alone does not constitute laches, 48 *Corpus Juris*, 331. Accompanying the lapse of time in the case at bar has been a litigation against others for royalties under licenses concerning the patents in suit. While it is true that the validity of the patents could not be attacked in such suits, the attack made by the defendant there was based upon the same prior art and the same kind of defenses raised in the case at bar. Delay in the prosecution of other suits for infringement of the same patent. 48 *Corpus Juris*, 333, citing *Plecker v. Poorman*, 147 Fed. 528 (C. C. Ohio, 1905), *U. S. Mitis v. Detroit*, 122 Fed. 863 (C. C. A. 6, 1903).

Laches like any other equitable defense must be maintained in equity and good conscience. Here the defense is admittedly maintained by the National Automobile Chamber of Commerce, of which General Motors Corporation, defendant in the prior cases has been a member prior to the beginning of all litigation on these patents (plaintiff's Exs. 57-8). The several members of the Chamber contribute to the defense of patent suits which are defended by that body. *Reo v. Gear Grinding*, 42 Fed. (2) 965 (C. C. A. 6, 1930).

Such being the relationship between General Motors and Nash Motor, the real defendant here, both being members of the Chamber, plaintiff should not be penalized and this defendant cannot be heard to take advantage of a situation created by one of its privies, where

plaintiff elected to pursue the General Motors and establish its rights on issues which also arise in this litigation. In *Frank V. Smith v. Pomeroy,* 299 Fed. 544 (C. C. A. 2, 1924) Judge Manton says at pg. 547:

> "* * * that the appellant was excused for the delay in suing for infringement by reason of the previous Yates litigation, taken in connection with the concurring circumstances above described. We regard these facts and circumstances as justifying an appeal to the conscience of a court of equity as a sufficient excuse for the delay. Such delay should not work to the advantage of one who has fraudulently and deliberately infringed, and who has stood behind and actively participated in a stubborn attack upon the validity of the patent by another litigant. They should not profit by the appellant's helpless condition, nor be permitted to escape from the results of their wrongdoing."

CONCLUSION.

This case for the first time tests the validity of the Swan patents. In the second *General Motors* case the Commissioner concluded his report with this statement:

> "Judge Westenhaver, upon mature deliberation, found that Swan sought to, and did solve the problems in the existing art in manifolds by introducing a new and original principle of operation. He found the gist of the Swan invention to consist in bringing the gaseous mixture from the carburetor to the header in perpendicular or straight lines, then abruptly changing its course at right angles in the header, and then again changing its course at right angles from the header into the branches. Having before him the judgment and the opinion in the former case, with the affirming opinion on appeal by the 6th Circuit Court of Appeals, the Commissioner would be presumptuous, indeed, to attempt to set them aside, or even not to give full effect to these judgments."

Notwithstanding the new proof offered in this case, the so-called Tice tests which have shown better the phenomena of the action of forces in a manifold than it has ever been shown before, the Swan patents are found to be improvements giving "commercially equal distribu-

tion," if not "scientifically equal distribution," and are entitled to the protection of the court.

Many protracted hearings have been held in this proceeding and the testimony has covered a wide range. Tests were made which the Master attended and there observed the operation of manifold apparatus, and the results of the tests are offered in evidence. Some of the evidence has been received over objection, so that the court may have before it all of the claims and the proof offered by both parties. Claims of new issues in this case, supported by new evidence, have been heard at length by the Master, for it was believed by all parties that a full and complete hearing should be had in this proceeding.

The Master reports that on the 30th day of June, 1933, he handed draft copies of this report to counsel and asked that errors and corrections to be made be pointed out by counsel by July 12th, 1933, that the Master might consider and make such corrections insofar as the Master believed proper and in keeping with the views as expressed in the report. Such suggestions have been received and corrections made in the report, and thereafter, again on July 25th, 1933, draft copies of the corrected report were handed to counsel with the request that errors and corrections to be made be pointed out by August 3rd, 1933, and such suggestions have been received and the corrections made. Two copies of this report have been furnished to counsel for each party.

Herewith I hand up for your Honors the following:

(1) Original files and papers from the Clerk of the Court.

(2) Stipulation.

(3) Transcript of testimony, together with plaintiff's exhibits Nos. 1 to 168, inclusive, and defendant's exhibits Nos. D-201 to 410a inclusive.

(4) Briefs of Counsel.

(5) Suggested Findings of Fact and Conclusions of Law submitted by counsel.

(6) Report of Special Master.

Respectfully submitted,

WM. B. WOODS,
Special Master.

August 21, 1933.

On Manifolds and Distribution.

How the Manifold Action Is Limited By and Must Coordinate With the Carburetion. Why It Is That All of the Cylinders of An Engine Are Not Served Equally.

By P. S. Tice.

THE matter of distributing the mixture to the cylinders of an engine by a single piping system or manifold has always been one of considerable interest; and those who have set themselves to evolve a "pipe" that would be sensibly perfect in its distributing action have learned some very interesting and important things. With the coming in and increasingly more general use of the six-cylinder engine, the problem assumed more serious aspects than had been the case in the supply system of the four—though it is a matter of common knowledge and experience that some of the earlier types, notably the two-cylinder opposed, were very "difficult," to say the least, because of defective manifolding.

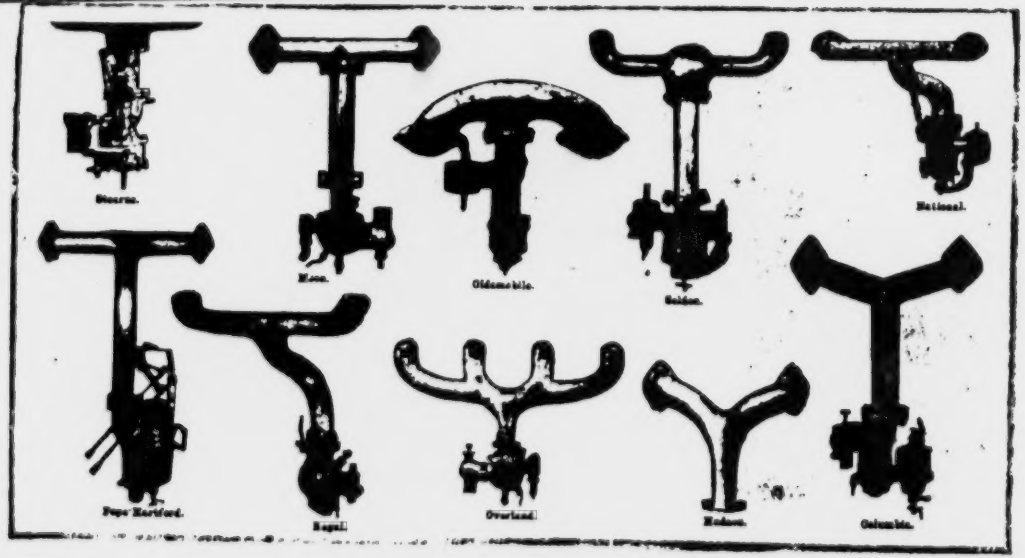
The irregularities of motor action growing out of the use of a piping system that is deficient as a distributing device are many and most annoying. In the first place, the combustion chambers of an engine are made all of a size, so that the compression pressures shall be of the same value in each. This equality of compression pressures among the cylinders is of great importance, since upon it depends the "smoothness" of the running action. Considering only the relative compressions, it is obvious that, given synchronous ignition and the same quality of mixture in each of the cylinders, the relative values of the maximum and mean cylinder pressures depend upon the compression pressures. If these latter are of the same value in each cylinder, the pressures upon combustion will be identical in each, and the result will be a series of equally spaced equal pressures—a result conducive to smooth, quiet action. But if the cylinder pressures are variable among themselves, neither smoothness nor quiet will be had, because of the consequent irregular variations in torque reaction and the variations in the sounds of the several exhausts. It is a well established fact in muffler design that the sensation of sound in the muffled exhaust of

an engine is due to the fluctuations in the pressure of the exhaust—the wider the fluctuation the greater the sound, and vice versa.

The "limping" sound of the exhaust is merely annoying, and is in itself of no great consequence. But the unevenness of the torque reactions of the several cylinders is a matter of consequence. Its effects are most strongly felt when the engine is operating at a low or medium speed under full load. And it is manifest by an increasing proneness to vibration—the vibration of torque reaction, which has nothing whatever to do with the running or rotative balance of the engine—as when climbing hills or running in sand. Very naturally such running is inefficient running, since torque reaction variations are not normally caused by increases in the effective cylinder pressures, but by reductions in them induced by, in this case, compression losses due to cylinder leakage or unequal restrictions of the effective passages to the cylinders.

At this point it should be said that, considering the manifold as a distributor of gas, air, and not as a distributor of "mixture," it is a very bad design indeed that will so distribute or fail to distribute as to cause a notable variation among the compression pressures of the cylinders. Gases have so little inertia and are so mobile that, as far as *quantitative* distribution is concerned, there is but little to choose between the forms of piping that are used. Of course, if the passages to some of the cylinders are much more tortuous or restricted than those to the other cylinders, less charge will be aspirated by the former cylinders, with a reduction in the available compression pressures. But if the passages are practically equal in length and the bends in each are equal in number and mean radius, and the effective areas are the same throughout each of them, there can be no difficulty arising because of unequal quantitative distribution.

Of course, the straighter the several pas-



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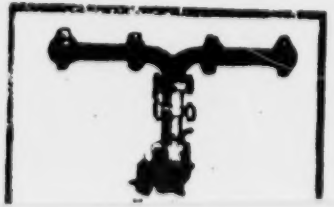

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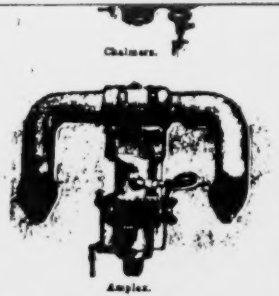
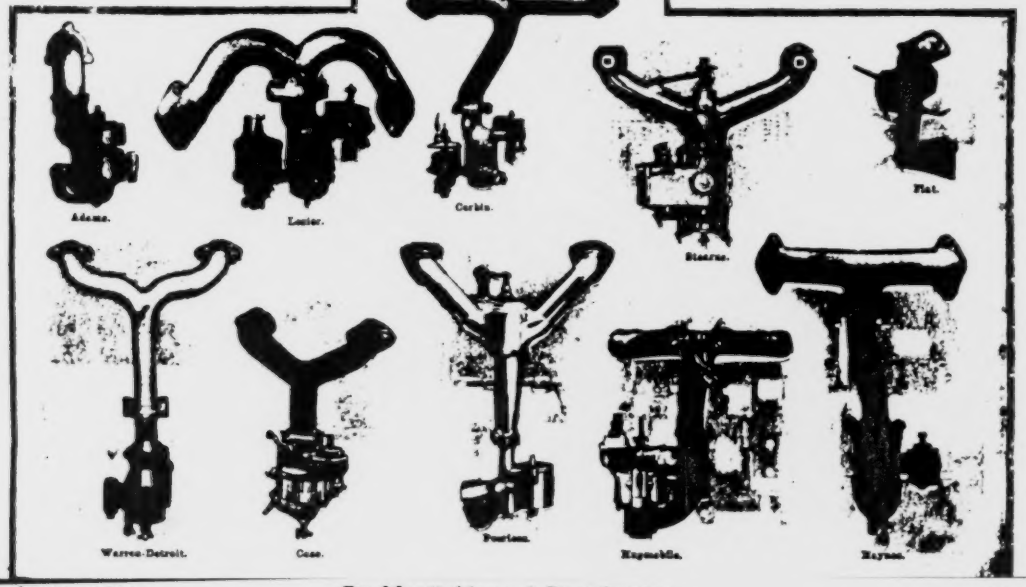
The "limping" sound of the exhaust is merely annoying, and is in itself of no great consequence. But the unevenness of the torque reactions of the several cylinders is a matter of consequence. Its effects are most strongly felt when the engine is operating at a low or medium speed under full load. And it is manifest by an increasing proneness to

seen to be equal to the loss through 2x3x 35.09=210.5 inches of straight pipe. With a charge velocity of 5,000 feet per minute, which value is often exceeded, the loss per 100 feet of 2-inch pipe is very approximately 1.13 pounds. The total pressure loss through the branch is therefore 2.37 pounds, exclusive of that in the straight part. The true significance of this is seen with the aid of a bit of calculation. In an engine cylinder having a ratio of total cylinder volume to combustion space volume of 4.44, the compression pressure will normally be 80 pounds per square inch gauge if the pressure within the cylinder at the time of starting the compression stroke is atmospheric. But if it is reduced by the amount of the above loss, which represents only that part of the loss occurring in



distribution is unaffected by the presence or absence of fuel in the mixture, since it deals simply with volumes of gas—air in this case. But qualitative distribution, which, as has been stated, is by far the more important of accomplishment, has to do with both the fuel and the air, and with the maintenance of the proportions as determined by the carbureter.

Qualitative distribution is, properly speaking, in our present day motor cars, a problem in carburetion, rather than in distribution pure and simple. It has been seen that equality of distribution is easy of attainment, quantitatively, in which the only consideration is an arrangement of piping that will convey equal quantities of a gas from a single supply source to several points. The matter of manifold design would be solved completely therefore, if the mixture were a gas or could be



segue and the more reasonable the effective areas, proportioned to the quantity of gas handled, the greater will be the quantity of mixture that can be aspirated by each of the cylinders—particularly under the condition of high speed, when this matter becomes of prime importance as determining the power output and efficiency of the engine. It is interesting in this latter connection to note the results of experiments conducted for the purpose of determining the losses in pipes due to bends. As tabulated by the experimenters, the loss due to a single 90 deg. bend, the mean radius of the bend being stated in terms of the diameter of the pipe forming the bend, is expressed as an equivalent length of straight pipe, in terms of the pipe diameter, imposing the same loss:

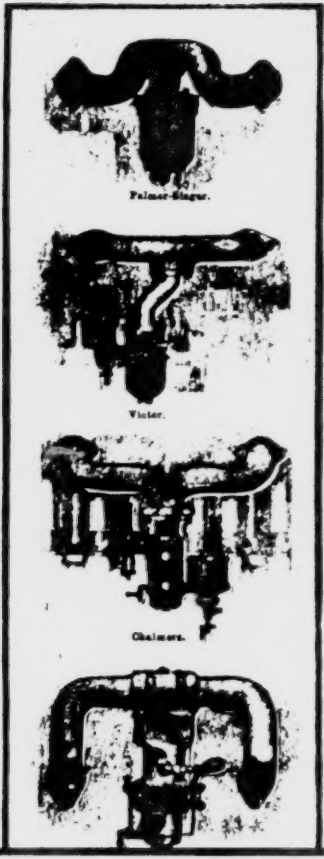
Mean radius of bend:

.5 .75 1.00 1.25 1.50 2.00 3.00 5.00

Length of straight pipe:

121.2 35.09 17.51 12.72 10.36 9.03 8.24 7.85

For the sake of pointing the significance of these figures, let us take as an example an intake pipe of 2 inches diameter. If now the number of 90 deg. bends in each passage between the carbureter and the valve port itself is three (about the minimum found in practice), the loss will be equal to that in a length of 2-inch straight pipe represented by 2x3xthe number under that representing the mean radius of the bend, in the table above. Let us assume that the mean radius of each bend is equal to .75 of the pipe diameter—very approximately the average value employed. The resistance or loss through each branch, neglecting that through its straight portion, is now seen to be equal to the loss through 2x3x 35.09=210.5 inches of straight pipe. With a charge velocity of 5,000 feet per minute, which value is often exceeded, the loss per 100 feet of 2-inch pipe is very approximately 1.13 pounds. The total pressure loss through the branch is therefore 2.37 pounds, exclusive of that in the straight part. The true significance of this is seen with the aid of a bit of calculation. In an engine cylinder having a ratio of total cylinder volume to combustion space volume of 4.44, the compression pressure will normally be 80 pounds per square inch gauge if the pressure within the cylinder at the time of starting the compression stroke is atmospheric. But if it is reduced



the manifold branch, the compression will be but 64.8 pounds.

That this is really a very conservative estimate, probably because of the character of the surfaces of the cast passages, can be verified by anyone by connecting in the two legs of a manometer, one near the carbureter and the other with the cylinder port passage. In one particular form of manifold that was once very popular with makers of "sixes," the pressure loss through the manifold, in this way, with full throttle and maximum engine speed, was found to be 6.03 pounds. This last was, of course, an exaggerated case; but it and the foregoing on bend losses serve to point most significantly to the proper procedure in the design of this part of the engine, and to the losses and possible defective distribution that may be experienced.

While the above is very pertinent to manifold design, it by no means explains the chief cause of inequality of charge distribution. However tortuous the passages, or however great the loss through each, it is always possible to make them all alike in their effects on the quantitative distribution. In fact, this is almost invariably done. But, anomalous as it may seem, those manifolds whose makers have been to the greatest pains to secure equal passage lengths are apt to be the worst offenders as regards distribution. This is because, in the case under consideration, there are two kinds of distribution, the quantitative, as discussed above, and the *qualitative*, which latter deals with the qualities or proportions of the mixture as delivered to the several cylinders of an engine. Quantitative distribution is unaffected by the presence or absence of fuel in the mixture, since it deals simply with volumes of gas—air in this case. But qualitative distribution, which, as has been stated, is by far the more important of accomplishment, has to do with both the fuel and the air, and with the maintenance of the proportions as determined by the carbureter.

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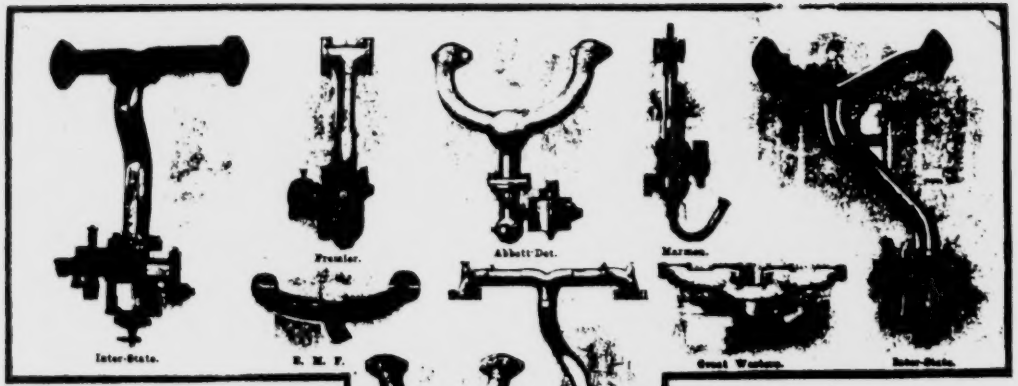

handled only as such. And it would and could be thus handled if the mixture were a true one—a mixture of fuel vapor and air. Gases and vapors obey the same laws, and where one is mixed with the other the action of the mixture, under all of the conditions involved in the supply system of an engine, is identical with that of a single gas. For this reason a true mixture of air and fuel would be distributed equally, in any sense of the term, by any piping system having equal effective passage lengths. That this much-to-be-desired result is not attained is attributable to the fact that the "mixture" is not a mixture in the proper sense of the word.

With the ordinary types of carbureter nozzles the fuel is ejected in a fine stream. Upon leaving the nozzle the fuel is at once subjected to a reduction of pressure, and a relatively small portion of it is vaporized by this agency—for the same reason and after the same manner that water can be made to vaporize more readily at great altitudes than at sea level. Also, evaporation is at once started through the absorption and utilization of the heat in the air with which it comes into contact. But so long as the fuel persists as a stream, the rate of vaporization is so very low as to be but little short of negligible, since conditions are not then favorable

ing shall have nothing but a mixture of air and fuel vapor to handle, is a practical impossibility. In practice the entrained fuel and that which is spread over the passage walls must also be manifolded, as well as that which is really vaporized and therefore behaves in the piping as does the air itself. It is that part of the fuel remaining as a liquid when bends and branches are to be negotiated that causes all of the trouble—and the more liquid there is the greater will be the trouble.

Within the mixture supply system of an engine, the air component, and also that part of the fuel that is vaporized, is caused to flow by virtue of the pressure difference between the two ends of the system. The force causing this flow is measured by the degree of vacuum caused by the motion of the pistons. But the fuel that is not vaporized moves only by virtue of the frictional contact of the moving air with it. Of the entrained globules those that are the smallest will move the fastest, since the smaller the globule the greater will be the ratio of its surface exposed to the friction of the air, compared with its weight. Further, it is readily conceivable that the globules, while existing as such, may be made mechanically or may become so small through progressive vaporization as to sensibly become a part of the air stream and

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But the time and temperatures involved are insufficient for this, and some of the fuel must therefore of necessity persist as a liquid in its passage through the manifold. Of course, the farther the fuel is made to travel in this way, the more favorable become the vaporizing conditions, since the entrained globules continually become smaller through evaporation, thus presenting more surface to the air in proportion to their volumes, and since, through progressive surface evaporation, the film of liquid that is spread over the surfaces continuously becomes thinner, thus again presenting an increasingly more favorable condition for heat transfer.

Even though these things are true, and are in fact the things that make the present type of supply system at all possible of use, this employment of surface carburetion in the manifold requires for its sufficient accomplishment a really very considerable length of passage. But a sufficient length of straight passage, so that the real manifolding or branch

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Even if it were possible initially to entrain the fuel as it left the nozzle of the carbureter, by far the greater part of it would be thrown upon the wall in its passage past the throttle valve, unless the valve were fully opened. Butterfly throttles are now practically universal, but at all positions, except the fully open and those most nearly approaching it, they act as most effective deflectors and at once "clean" the air column of entrained liquid, depositing it upon one side of the passage wall. Needless to say, the fuel continues in contact with the wall, though in its flow under the influence of air friction it tends to spread circumferentially over the surface of the passage. If the passage in which this first wall contact is had is long enough, is straight and is vertical, the fuel will ultimately be evenly distributed over its surface. The fact that practically all of the fuel supplied is forced by the throttle into direct contact with the wall of the passage above the carbureter, accounts for the great improvement in vaporization that is had when this passage is long and is hot-jacketed. The walls then provide the most direct course of heat flow to the fuel for its vaporization. If the fuel were wholly entrained in its passage through this

part of the piping, the effect of the hot jacket would be negligible, since practically none of its heat could then be communicated to the fuel.

Coming now to a branching of the way in the intake manifold, the point in the system is reached where imperfect qualitative distribution can or does start. Whether it does or does not depends upon conditions in the passage leading to the meeting of the branches. As stated before, and repeated here for emphasis, there will be no inequality of distribution if the content of the main passage is comprised of a mixture of air and fuel vapor. But if liquid is present, the equality or inequality of the distribution at this point depends upon the manner in which the liquid is made to approach the branching. We have seen that the greater part of the fuel is in contact with the wall in the main passage, due to the deflecting action of the throttle valve, and also that the relative amount of it that is localized, so to speak, upon one side of the passage depends, inversely, upon the length of the passage before the branching is encountered, and upon the amount of closure of the throttle.

The obvious thing for the fuel to do is to adhere almost wholly to the wall, in a passage of so little length. If it is a T branching with the axis of the throttle spindle perpendicular to the plane of the T, and the throttle disc is so inclined that the fuel is thrown upon the left wall of the vertical passage, the unvaporized fuel remaining in the passage at the branching will be almost wholly aspirated into the left branch when the main flow of air is in that direction; while, when the flow is in the opposite direction, to the right, but very little of it will be taken into the latter branch. This is because of the tendency of the liquid to adhere to the wall when once in contact with it, and because of the tendency of the entrained globules to persist in their rectilinear motion when the turns are at all sharp. The result in such a case is that the cylinder or cylinders supplied by the left branch will normally work on richer mixture than will those to the right. If the throttle is set so that the disc inclines the other way, conditions will only be reversed, and the cylinders at the right will then receive the richer mixture.

Locomobile.

Diesel Car.

Garford.

The above is a condition that [illegible]

than that which will give the best results, in order that the enrichment of the mixture through the other branch may not be so great as to cause misfiring; and, vice versa, the enrichment may not be reduced by carbureter adjustment without so impoverishing the mixture to the other side as to cause failure of ignition. If it were not that a considerable range of proportions can be employed in the "mixture" the engine would cease to act under the above conditions. Needless to say, on both the impoverished and over-rich sides, inefficiency is had through reduction of the combustion pressures.

In the above case it was taken that the throttle spindle was set perpendicularly to the plane of the branches. It is quite obvious that if that spindle is set with its axis in the plane of branches, that part of the fuel adhering to the wall will have the same opportunity to enter either of the branches, and localization of the chief mass of the liquid will not necessarily adversely affect the distribution at this point of first branching.

After the "mixture" has negotiated the first branching, with or without alterations in its original proportions, there still remain other branchings which may further subdivide evenly or unevenly, any liquid reaching them. Naturally, a somewhat lesser amount of liquid will have to be handled in the further branchings, since surface vaporization will have been going on as the mixture components progress along the branches. As it approaches the cylinders the liquid will encounter warmer surfaces, which further aid in vaporization. But for the liquid that does remain, the same rules as above will apply. Whatever is entrained as globules and whatever remains upon the walls will seek the outer radii of all curves, and, if the earlier distribution has been particularly poor, this may result in so great an enrichment of the mixture to one of the cylinders as to make it unduly sensitive to even the slightest changes in proportions.

Obviously the layout of the manifold is responsible for the perfection of the distribution, since it must handle what the carbureter gives it; but the fact remains that the carbureter imposes unwarranted duties upon the manifold. Even so, when the respective physical states and actions of the air and the fuel as supplied are understood, the

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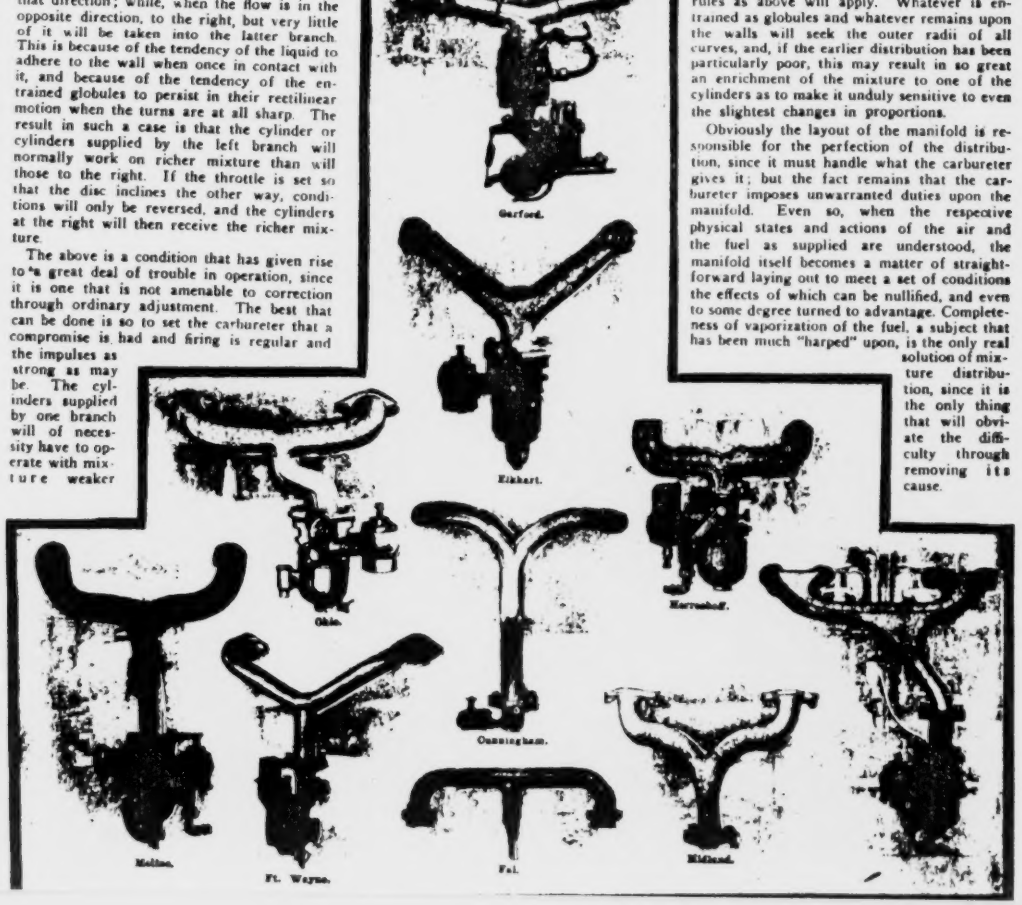
The above is a condition that has given rise to a great deal of trouble in operation, since it is one that is not amenable to correction through ordinary adjustment. The best that can be done is so to set the carbureter that a compromise is had and firing is regular and the impulses as strong as may be. The cylinders supplied by one branch will of necessity have to operate with mixture weaker



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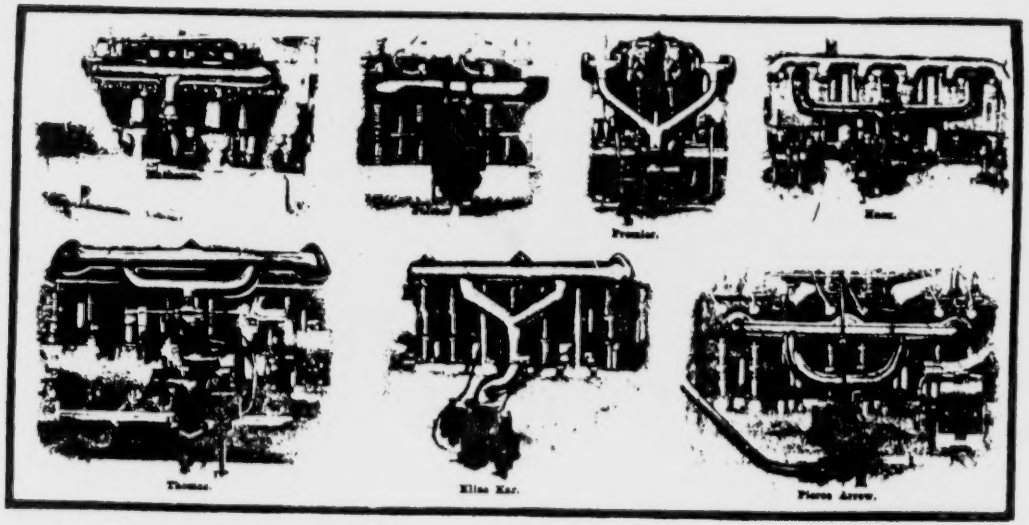

On Manifolds and Distribution.

Some Further Considerations of the Design of Intake Systems as They Affect the Equality of Distribution of the "Mixture" to the Engine Cylinders.

By P. S. Tice.

IN the article under the above title, which appeared in the April issue of MoToR, was embodied a discussion of the general characteristics of manifolds viewed as distributors of "mixture," and of the conditions that are imposed upon them by the carbureter. The chiefly significant points brought out were that the manifold is called upon to act as a vaporizer and to maintain the proportions in the mixture under conditions that are decidedly unfavorable to the attainment of such a result.

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is comparatively easy of fulfillment—the rub comes when it is attempted to combine them all in a single "pipe." The effects upon the distribution of the early and presumably necessary bends in the pipe can be corrected by the use of other bends, but these additional bends may disturb the quantitative action, and they most certainly impose additional aspiration losses. The passages must combine freedom and the quality of maintaining the mixture proportions at the same value in each branch. In a general way, dependent upon present carburetion methods, this means that the pipe must be as straight as possible and at the

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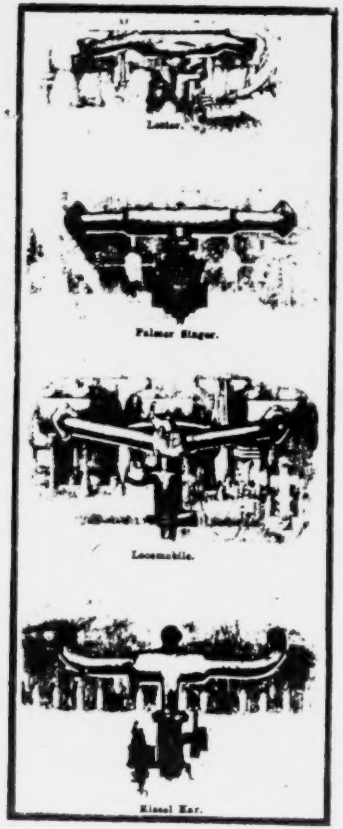
But very little analysis of the situation is necessary to indicate the magnitude of the conditions that make equality of distribution difficult. Throttle valves and bends both serve so to rearrange the mixture ingredients that extreme care must be employed in laying out the manifold if the separation of the liquid from the gas is not to give rise to defective distribution. Naturally, a judicious combination of bends in the piping can be made to give sensibly equal distribution. But where additional bends are used to offset the effects of other bends, there is an increased resistance to the passage of the "mixture" through the pipe, over that which would of necessity be experienced in a system requiring no such correction. And where correction of qualitative distribution is sought through the insertion into the system of bends or other deflectors intended to modify the flow of the liquid mixture component, the effective passage lengths to the several cylinders cannot but be altered among themselves, sometimes to a very considerable and serious extent. For a discussion of the losses due to bends, the reader is referred to page 11 of the April issue of MoToR.

The ideal intake manifold is easily specified. It is one in which equality of distribution is had, both qualitatively and quantitatively, and in which no unnecessary resistance is offered to the flow of the mixture. There must, of course, be some loss in pressure through the pipe, but the ease with which this loss can be augmented to almost prohibitive proportions, as indicated in the former article, points to the necessity of keeping it down to a minimum.

Any one or other of the above specifications



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Because of the generally more far reaching and adverse effects of imperfect qualitative distribution, as compared with failure in other directions, it is usual to sacrifice as much as may be necessary of freedom and equality of effective passage length to the attainment of the relatively much more desirable condition. This is a logical procedure, since it is a compromise between conditions that are not reconciled to each other, with a view to securing the best mean result.

The extent of such a compromise between the conditions, and the loss in freedom that must be borne for the sake of a working equality of qualitative distribution, is, as a rule, much greater in the supply system of a six than in the case of a four-cylinder engine. Likewise, the necessary loss in freedom of the passages becomes still greater as the number of cylinders is further increased. This is because of the increased number of ultimate branchings to the cylinder ports, and the therefore greater number of changes in direction of flow that must be made by the "mixture" before it reaches the final branchings.

If what was formerly said about the effect of a deflector, as the throttle, and the throwing to the outer radius of all curves of whatever fuel remained in the pipe as a liquid is remembered, the reason for this increasing difficulty with increasing numbers of cylinder will be quite apparent. If the piping could be arranged so that each time a branching was encountered the curve in the pipe approaching the branching lay with its axis in a plane per-

pendicular to the axes of the branches or bisecting the angle formed by them, the liquid content of the mixture would be divided equally between them, and the quality would not then differ in them. But, obviously, from space or other consideration, this method of arranging the piping is a practical impossibility throughout the whole system, even though it may be accomplished throughout the earlier branchings.

We have seen that the requirements for equal distribution at the branchings do not ordinarily fit in with the construction there possible, because of the fact that the liquid will seek the outer walls of the curved parts. Let us begin at the ends of the branches, the cylinder port ends, and reconstruct the pipe back to the carbureter.

Whether the cylinders are cast individually or in pairs with the ports siamesed, each port for the attachment of the intake pipe will lead to a symmetrically disposed passage or passages to the actual valve ports. There being no branching at this point with individually-cast cylinders, no trouble will be experienced here with them. But, in the case of the siamesed ports of a twin cylinder casting, it has been shown that the intake passage must be arranged with its curvature lying in a plane which bisects the angle between the axes of the branches. The only way practicable in which such a result can be accomplished where a pipe end is used for communication with the cylinder port is to lead the pipe over the cylinders, as is sometimes done. But this requires an additional pipe length and almost invariably makes necessary the use of more bends than would be the case with the ordinary "one side" intake system. But the fact remains that in this way only can a passage discharging from the end be made to deliver to the two cylinders with absolute certainty of qualitative equality.

Another solution seems to lie in the use of opposed branches leading to the same port, since it is then permitted to use a horizontal system all on the same side of the engine. Where two opposed branches lead to the same port, the outer radii of the curves also oppose each other, and it is manifestly impossible for more of the liquid to be swept into one valve passage than into the other, provided, of course, that each of the opposed branches carries the same amount of liquid. In this way can the distribution beyond the ends of the

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to aspirate a given quality of mixture. If the carbureter is connected in at one end of this common horizontal pipe, it is a foregone conclusion that the liquid content of the mixture will refuse to take the turns into the intermediate cylinders, but will, by virtue of its momentum and its persistence in rectilinear motion, pass them by, with the result that the cylinder nearest the carbureter will receive a relatively weak mixture, the one next it a slightly richer mixture, and so on to the end cylinder farthest from the carbureter which will aspirate the richest mixture of all, since there will be no other outlet for the unvaporized liquid that has swept past the other ports.

Furthermore, when the carbureter communicates with the center of this common passage, the same action obtains, though in a lesser degree, the *two* end cylinders tending to receive the richer charges. Then again, with this symmetrical connection of the pipe from the carbureter, the two branches leading from it to the cylinder ports may not be served equally because of defective distribution at the point of junction, as discussed in the former article, which condition may be so aggravated by other defects as to make it as bad as that had when

Aloe.

Franklin.

the carbureter is connected directly to one end of the common passage.

There is another method of using a single common horizontal connection between the cylinder ports that is coming rapidly to the fore. In this latter system the mixture from the carbureter is led into the two ends of the common passage, the complete pipe forming a so-called "loop" or "yoke." The action of this type of "pipe" is most interesting, and a study of it serves to show by what simple means an ordinarily difficult situation can sometimes be obviated. In its usual form it comprises two horizontal passages of equal lengths, the ends of which are connected by curved parts of as great a radius as may be desired. One of these horizontal passages is provided with right angle outlets to the several cylinder ports, and the other is connected at its center with the passage leading from the carbureter. In its entire makeup, between carbureter and cylinder ports, there are but four curves to be negotiated by the mixture, and two of these can be made of such a radius that the loss due to them is but little more than that in an equal length of straight pipe.

The effect of the throttle upon the distribution at the junction of the pipe from the carbureter with one of the horizontal members can be neutralized, as before shown, so that each side of the branching will be served equally. From this point on to the cylinder ports themselves there is but little chance for inequality to come into the action, providing the interior of the pipe is smooth and that it has been accurately made. Let us suppose one of the cylinders to aspirate its charge. Even though it be an end one, the mixture will flow to it from each side and through both right and left members of the horizontal passages, since the passage lengths, right and left, are practically equal in the matter of resistance to the flow of gas, which latter is the determining factor. With the mixture coming to the cylinder port in two opposed columns, each carrying the same amount of liquid unvaporized, it is evident that the tendency for the liquid to whip out of the column on one side will be counteracted by a like tendency in the liquid carried by the column on the other side, with the result that there will be no continuation of the liquid past the port for the undue enrichment of the mixture subsequently to be aspirated by some other cylinder farther along.

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The next point includes provision for making equal the qualitative distribution between the several cylinders or cylinder ports. From the very nature of the construction of an engine a single horizontal pipe connecting all of the cylinder ports is the most natural and most simple, and is also capable of being made most free. With such a pipe connecting all of the cylinders, the problem is how to supply the mixture to it so that each cylinder will be able

Alco.

Franklin.

Peerless.

though it be an end one, the mixture will flow to it from each side and through both right and left members of the horizontal passages, since the passage lengths, right and left, are practically equal in the matter of resistance to the flow of gas, which latter is the determining factor. With the mixture coming to the cylinder port in two opposed columns, each carrying the same amount of liquid unvaporized, it is evident that the tendency for the liquid to whip out of the column on one side will be counteracted by a like tendency in the liquid carried by the column on the other side, with the result that there will be no continuation of the liquid past the port for the undue enrichment of the mixture subsequently to be aspirated by some other cylinder farther along.

These then are the conditions that must be considered in the handling of the intake gas; and they are all, in so far as they are adverse, directly traceable to the imperfect manner in which our carbureters vaporize and mix the fuel with the air. If one has distribution difficulties to such an extent that they annoy, the thing first to be tried is some means of accelerating the vaporization of the fuel and improving the quality of the mixture. If the vaporization can be made sufficiently complete, it does not matter what sort of a manifold is used to get the mixture to the cylinders.

Thomas.

Wisconsin.

Stearns-Knight.

Winton.

Oldsmobile.